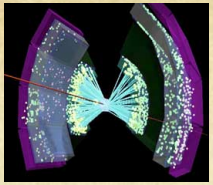
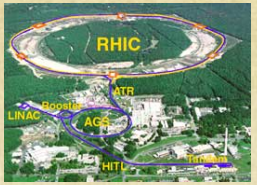


RHIC-AGS Users' Meeting 2012

Spin Workshop



PHENIX
ΔG measurements

Kimiaki Hashimoto

For the PHENIX Collaboration.

Rikkyo University/RIKEN

Table of Contents

- Introduction
- Experimental setup
- Recent PHENIX A_{LL} results
  - Mid rapidity@ 200 GeV
  - Cleaner channel for ΔG measurement.
  - Forward rapidity@ 200 GeV(lower Bjorken-X region)
- PHENIX New channel for A_{LL}
  - Di-π^0 (Sharper x coverage)

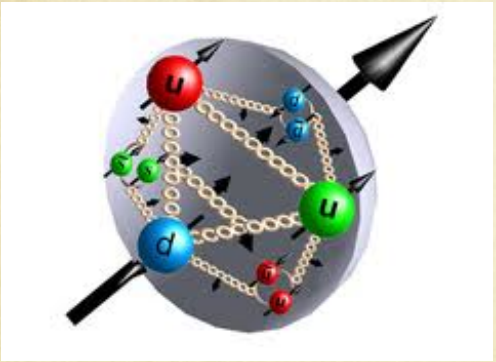
This talk is about contribution from gluon spin

$$\frac{1}{2} = \int_0^1 dx[\frac{1}{2}\sum_q(\Delta q + \Delta\bar{q})(x,\mu^2) + \Delta g(x,\mu^2)] + L$$

Proton Spin 1/2

Quark,anti-quark Spin

Gluon Spin

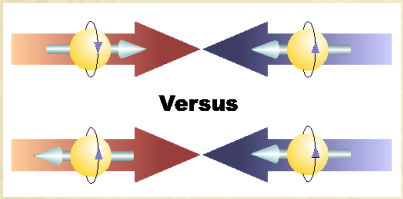


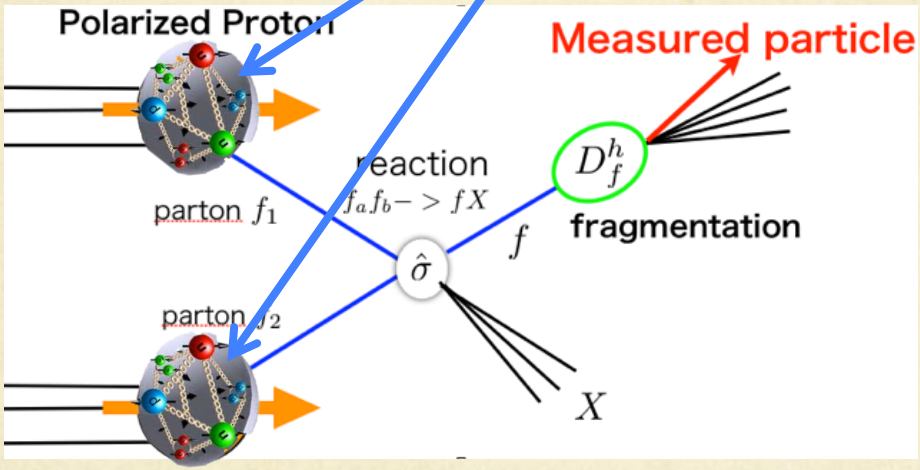
W boson production
(Next talk!)

$\pi^{0,\pm}$, η ,$h^{\pm}$,single electron and direct photon productions

A_{LL} consist of PDF

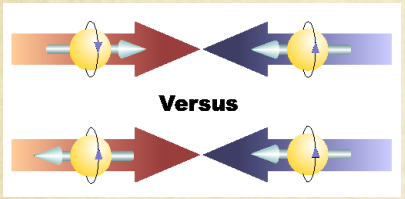
$$A_{LL} = \frac{\sigma^h_{++} - \sigma^h_{+-}}{\sigma^h_{++} + \sigma^h_{+-}} = \frac{\Sigma_{f_1,f_2,f} \Delta f_1 \otimes \Delta f_2 \otimes d\hat{\sigma}^{f_1 f_2 -> f X} \otimes D^h_f}{\Sigma_{f_1,f_2,f} f_1 \otimes f_2 \otimes \hat{\sigma}^{f_1 f_2 -> f X} \otimes D^h_f}$$

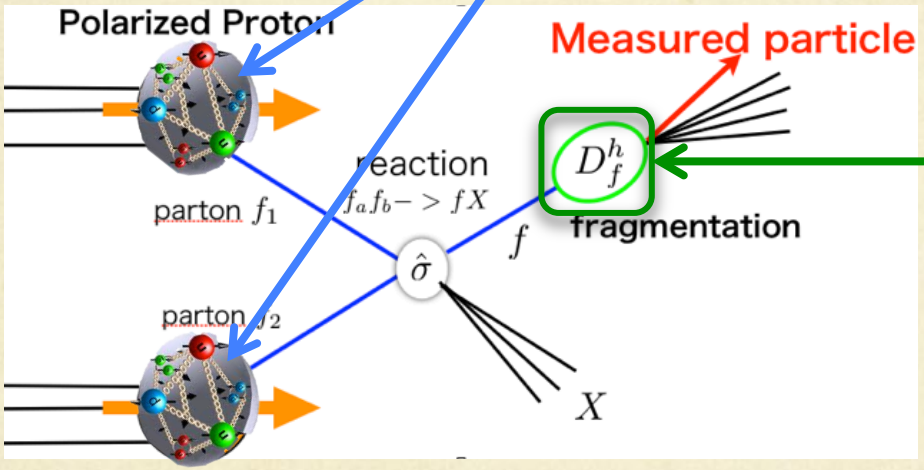




A_{LL} consist of PDF, FF

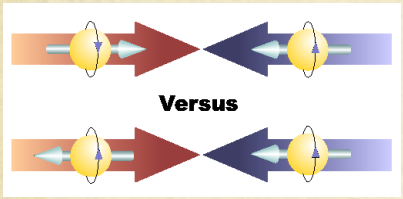
$$A_{LL} = \frac{\sigma^h_{++} - \sigma^h_{+-}}{\sigma^h_{++} + \sigma^h_{+-}} = \frac{\Sigma_{f_1,f_2,f} \Delta f_1 \otimes \Delta f_2 \otimes d\hat{\sigma}^{f_1 f_2 -> fX} \otimes D^h_f}{\Sigma_{f_1,f_2,f} f_1 \otimes f_2 \otimes \hat{\sigma}^{f_1 f_2 -> fX} \otimes D^h_f}$$

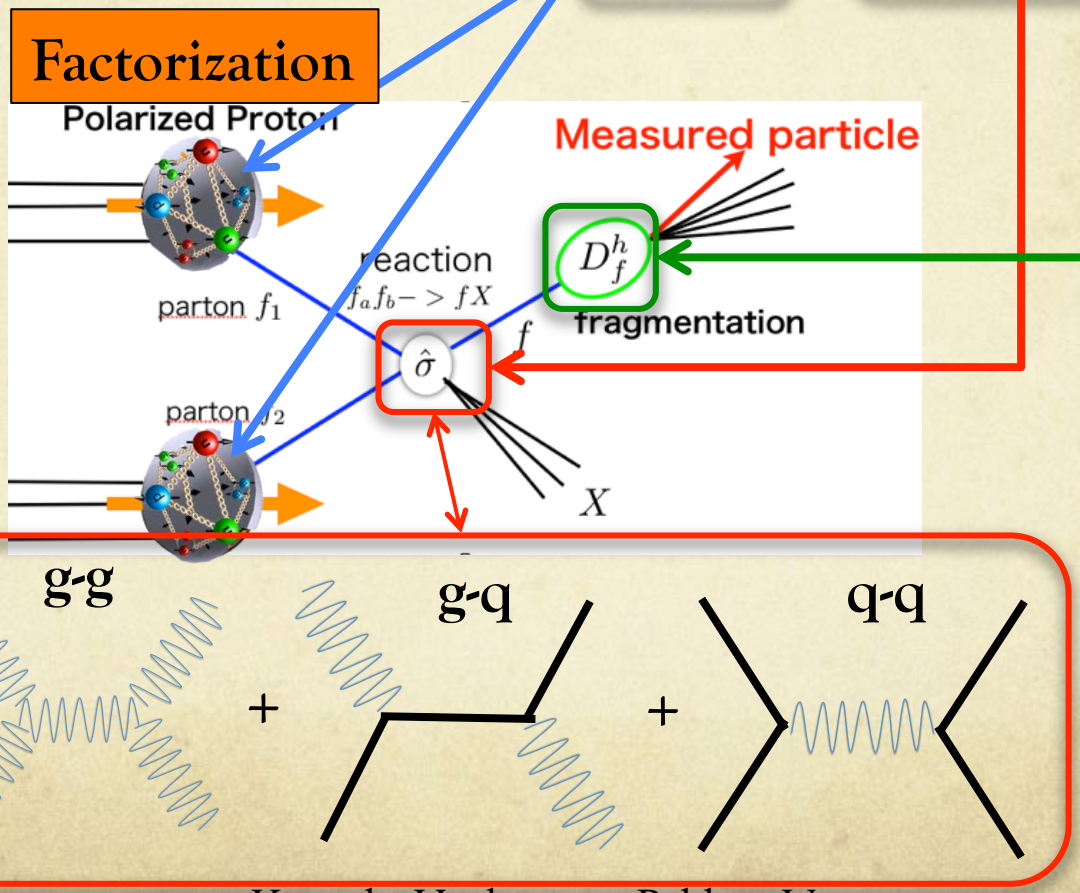




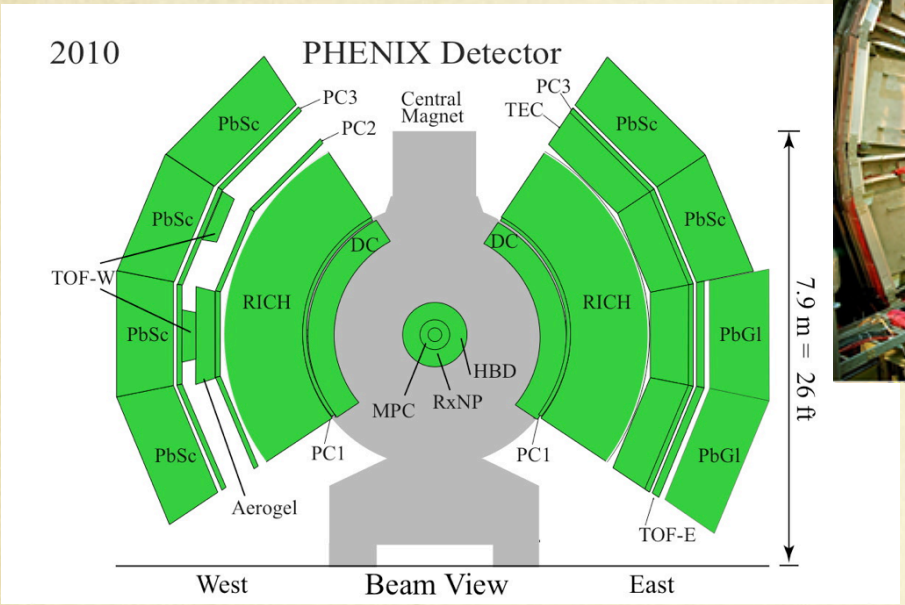
A_{LL} consist of PDF, FF , Partonic reactions

$$A_{LL} = \frac{\sigma^h_{++} - \sigma^h_{+-}}{\sigma^h_{++} + \sigma^h_{+-}} = \frac{\Sigma_{f_1,f_2,f} \Delta f_1 \otimes \Delta f_2 \otimes d\hat{\sigma}^{f_1 f_2 -> f X} \otimes D^h_f}{\Sigma_{f_1,f_2,f} f_1 \otimes f_2 \otimes \hat{\sigma}^{f_1 f_2 -> f X} \otimes D^h_f}$$





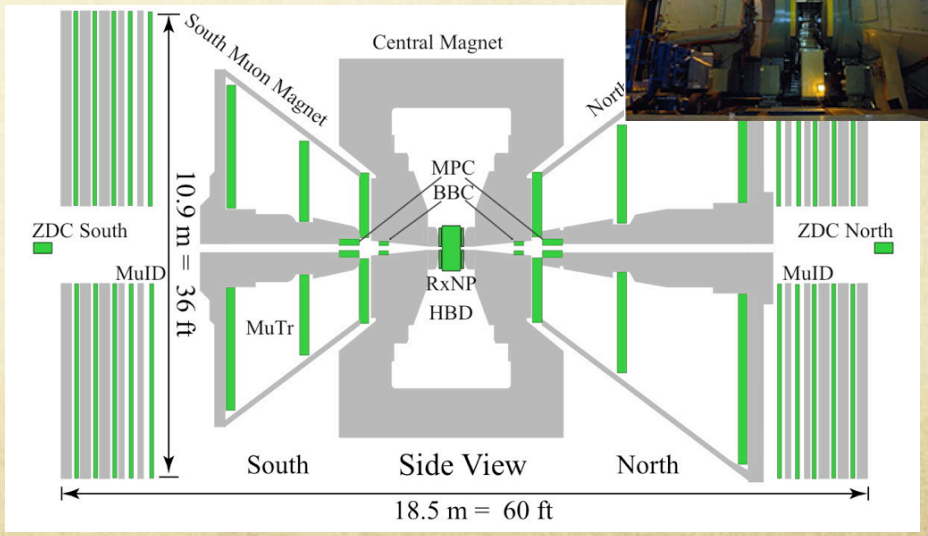
PHENIX detectors



Central Arm can measure $\pi^{0,\pm}$, η ,$h^{\pm}$,single electron, (W,Jet)productions (This talk!!)

MPC can measure cluster(This talk!!)

Muon Arm can measure W boson production (Next talk!)

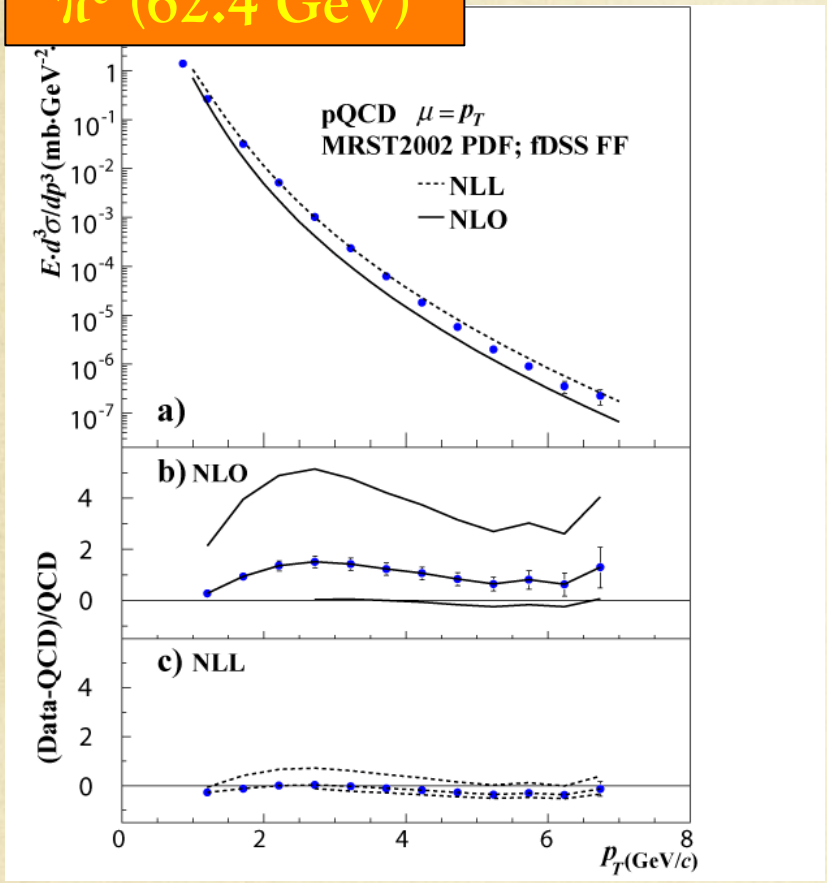


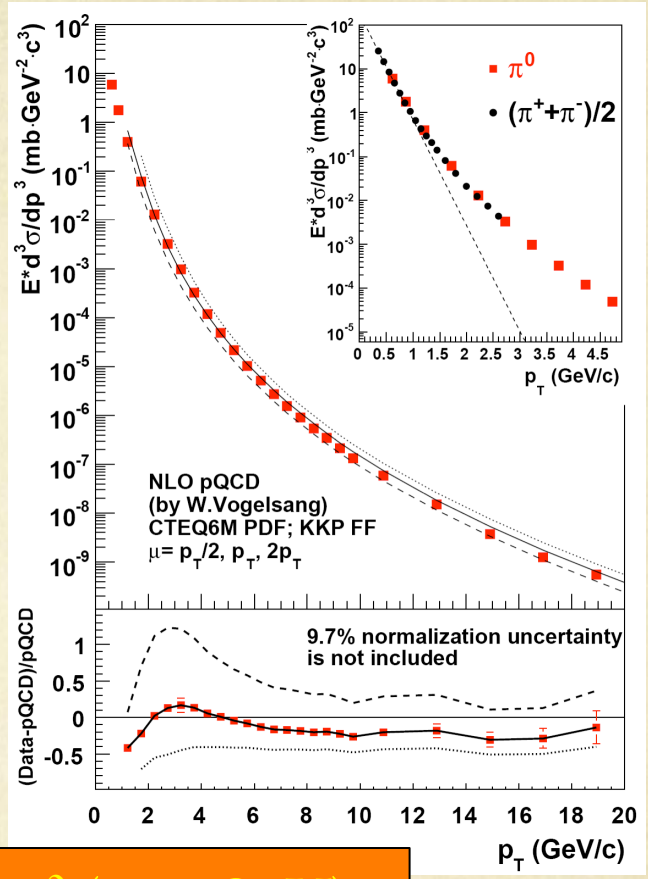
Cross section study in PHENIX

Kimiaki Hashimoto Rikkyo U.

pQCD can explain our data. (Factorization works well)

π^0 (62.4 GeV)

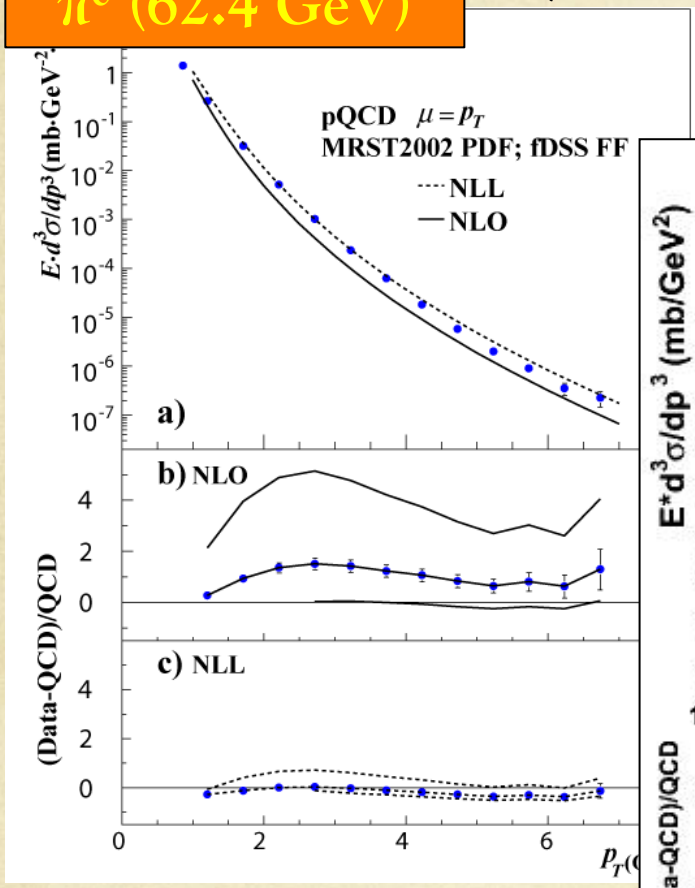




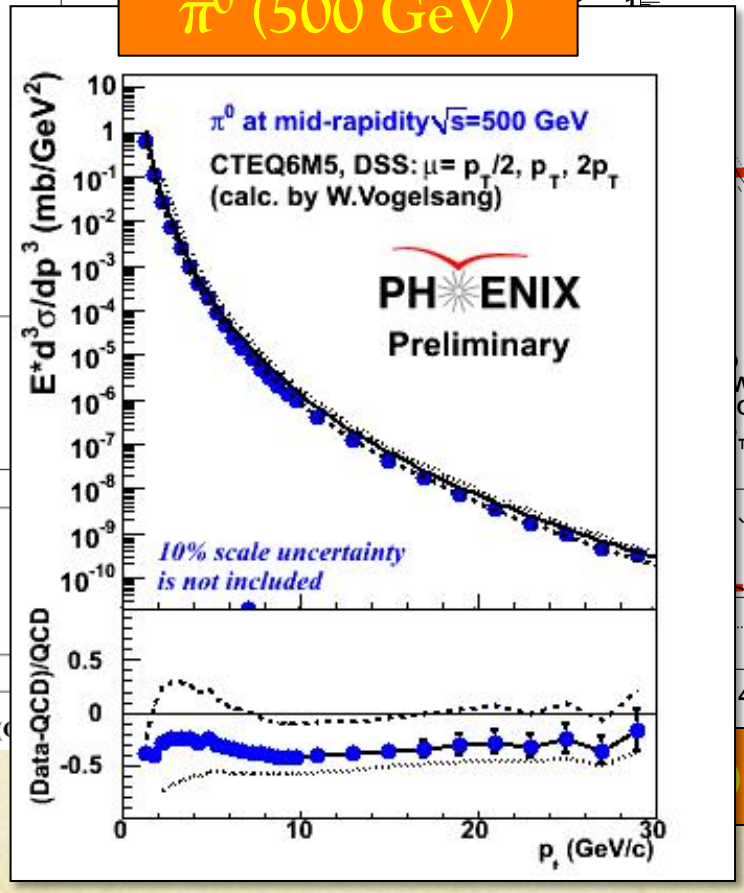
π^0 (200 GeV)

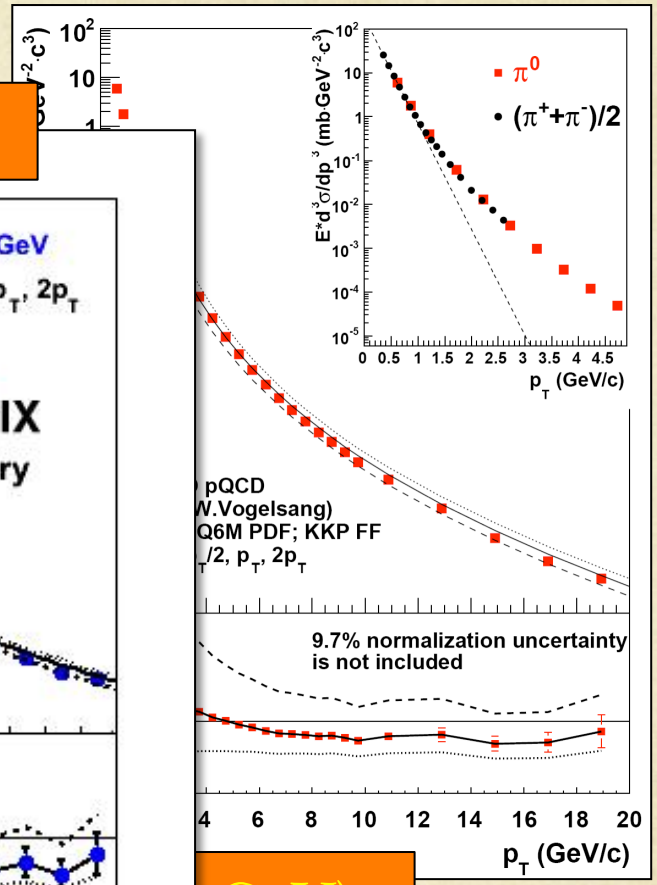
pQCD can explain our data. (Factorization works well)

π^0 (62.4 GeV)



π^0 (500 GeV)





GeV)

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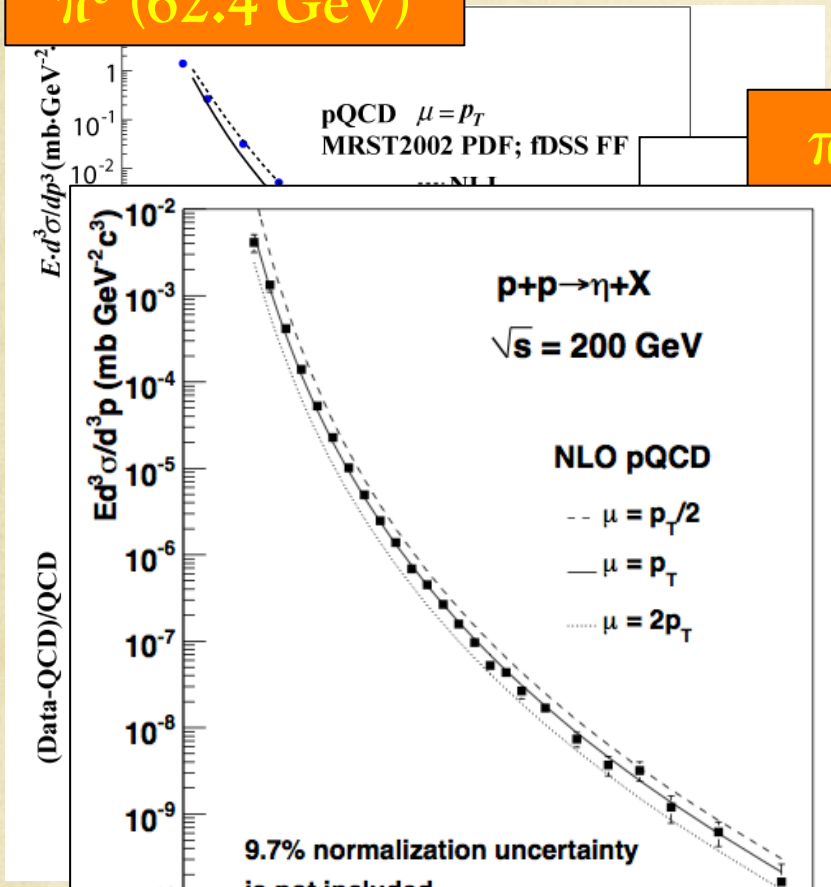
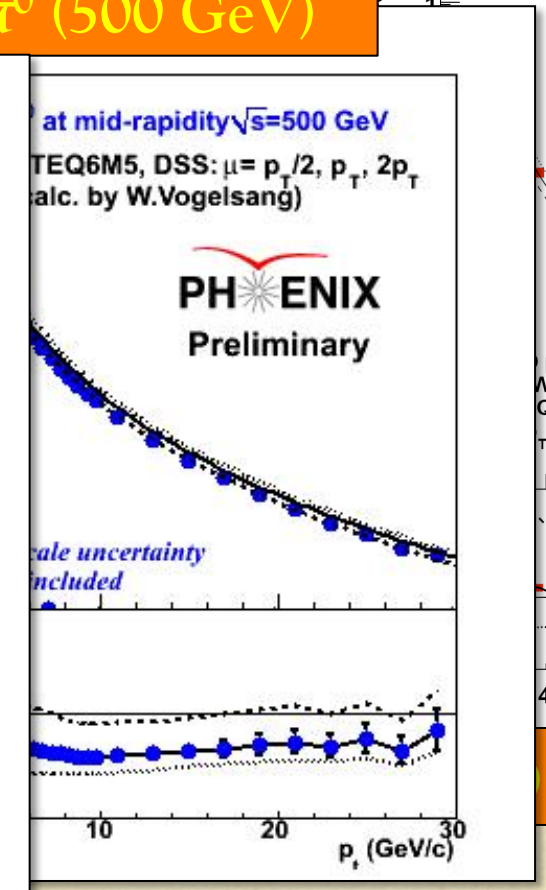
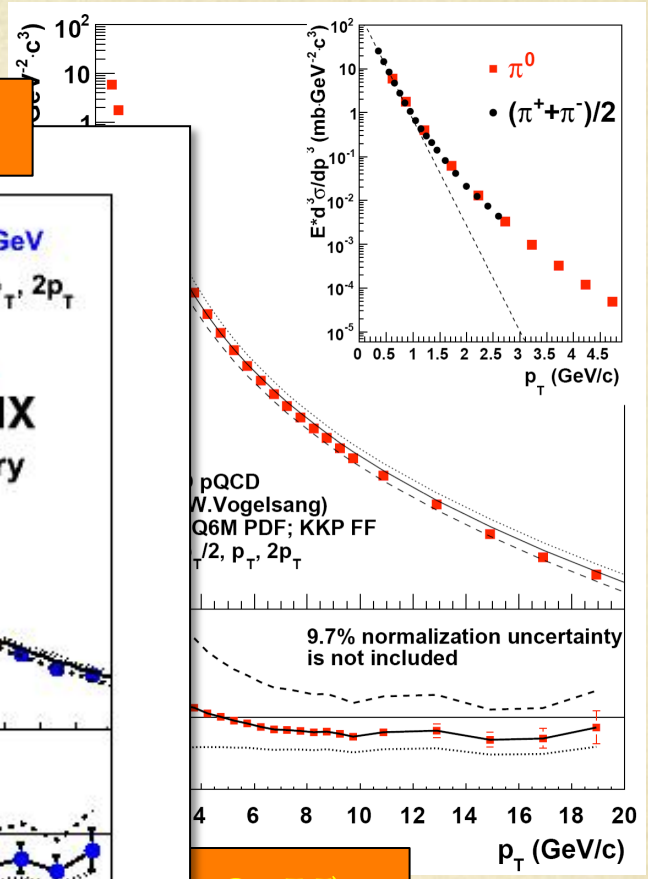


π^0 (500 GeV)



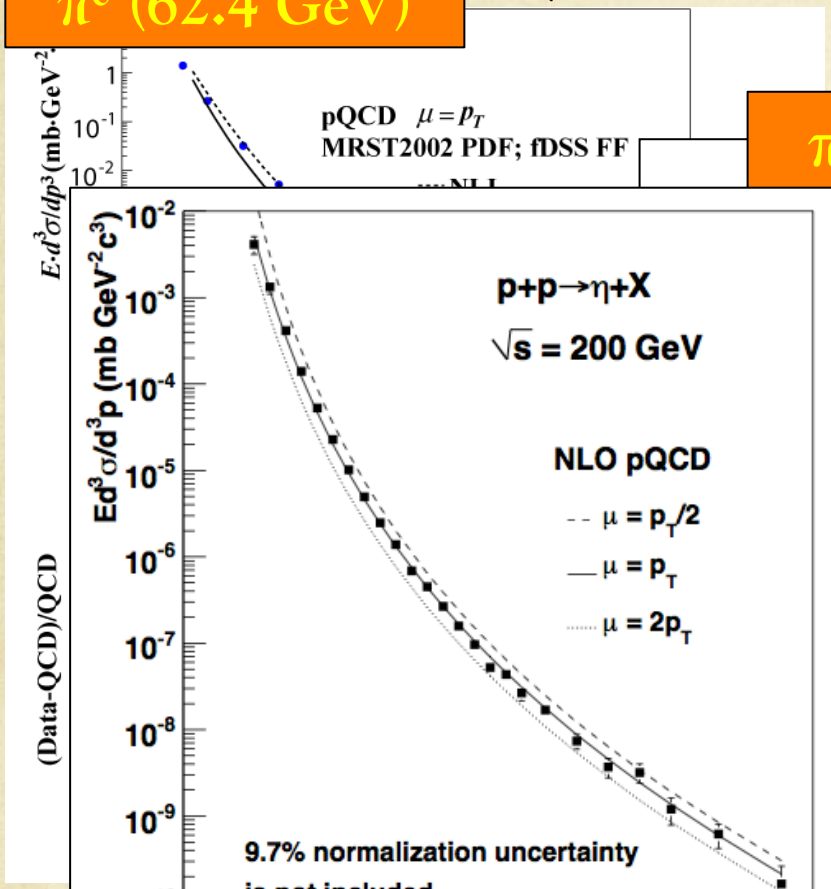


GeV)

η meson

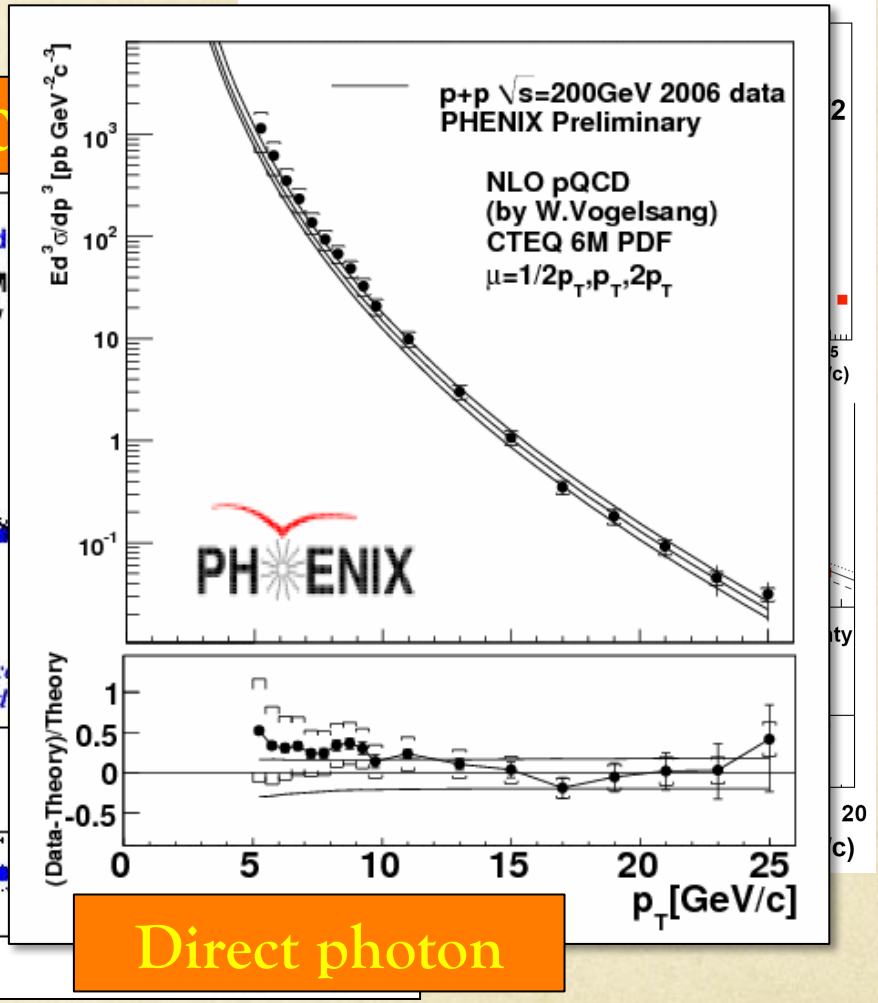
pQCD can explain our data. (Factorization works well)

π^0 (62.4 GeV)



π^0 (50

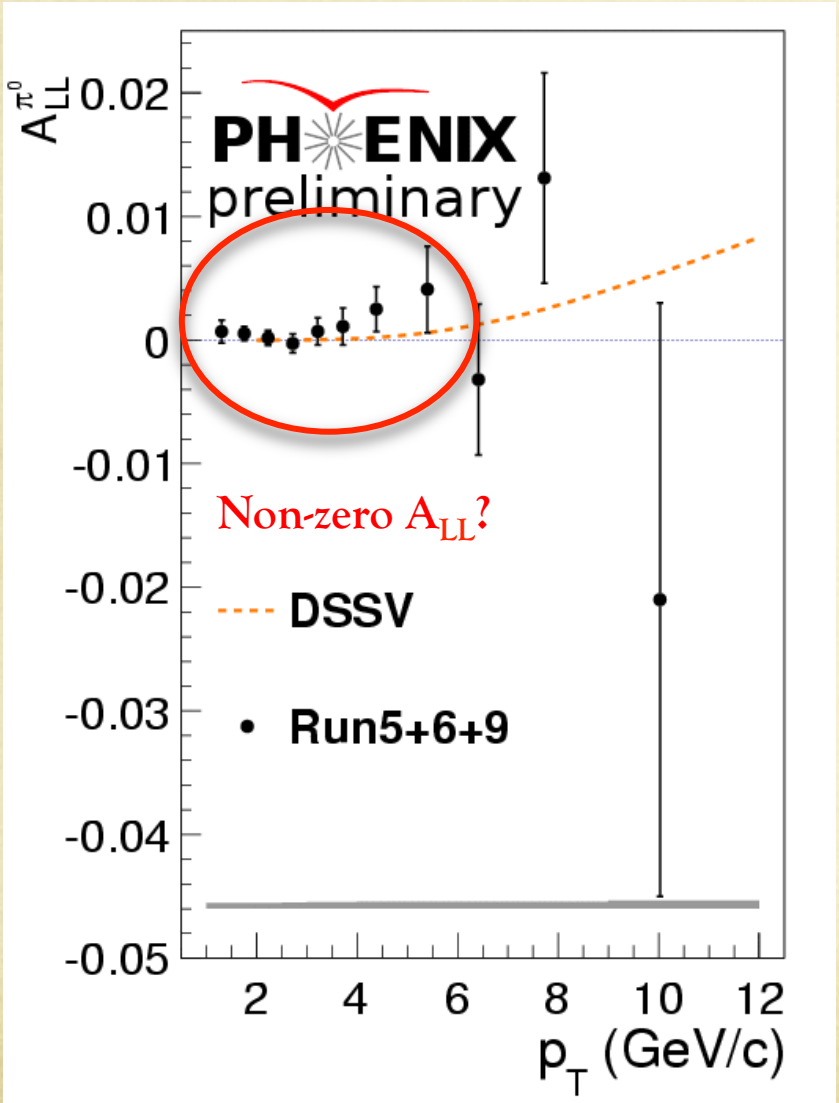
η meson



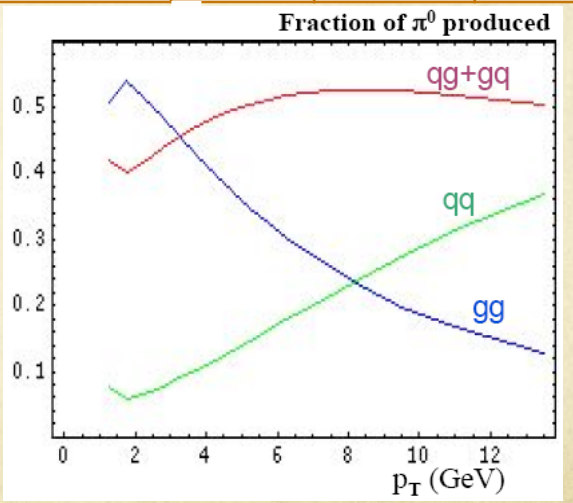
Direct photon

The recent A_{LL} results from PHENIX

The inclusive π^0 production have a large constrain of ΔG.

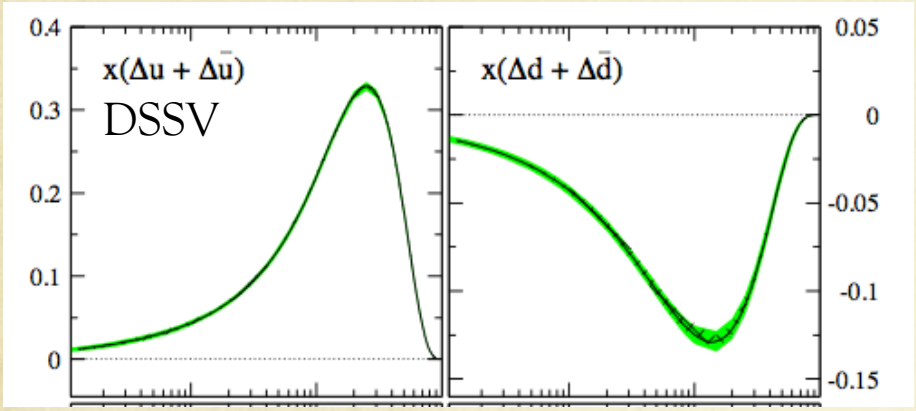


	$\sqrt{s}$ (GeV)	$\langle P_B \rangle$ (%)	$\langle P_Y \rangle$ (%)	L (pb^{-1})	FOM (P^4L)
Run5	200	50	49	2.5	0.15
Run6	200	56	57	6.5	0.66
Run9	200	57	57	14	1.5



gg scattering is dominant sub process at low pt.

The $\pi^{\pm}$ production have sensitivity for sign of gluon PDF



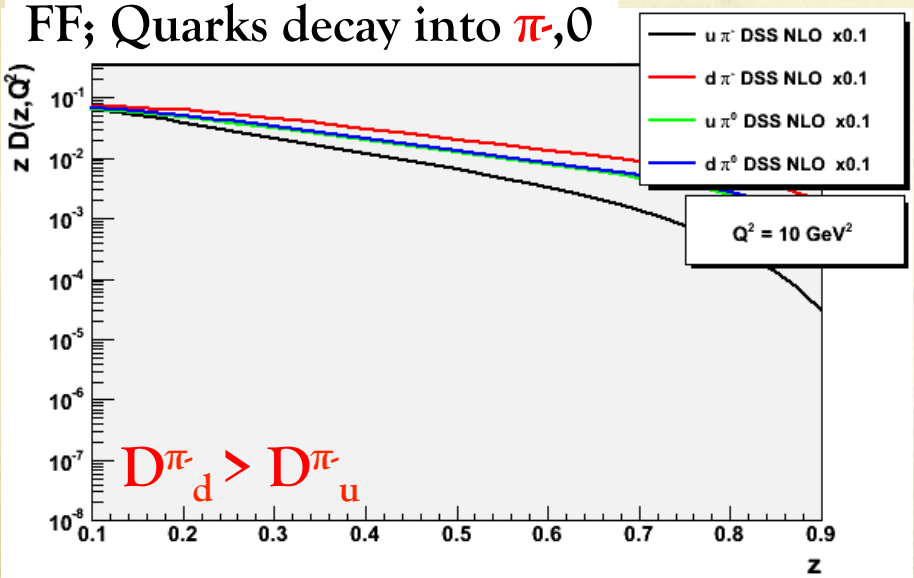
$$\pi^+ = u\bar{d} \quad \pi^- = d\bar{u}$$

- u-quark decay into π^+
- d-quark decay into π^-

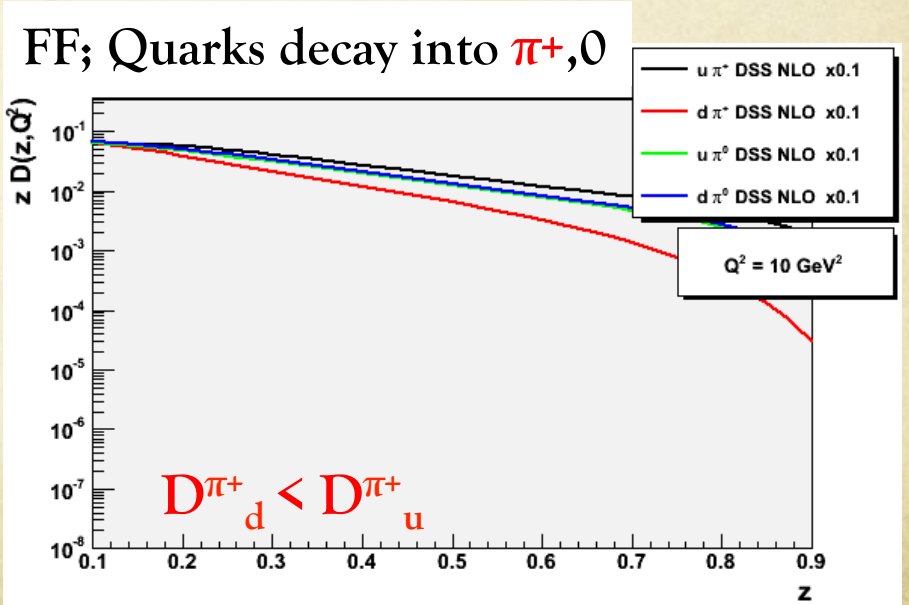
From sign of quark's PDF and FFs.

- $A_{LL}(\pi^+) > A_{LL}(\pi^0) > A_{LL}(\pi^-)$ for $\Delta G>0$
- $A_{LL}(\pi^+) < A_{LL}(\pi^0) < A_{LL}(\pi^-)$ for $\Delta G<0$

FF; Quarks decay into π^-,0



FF; Quarks decay into π^+,0



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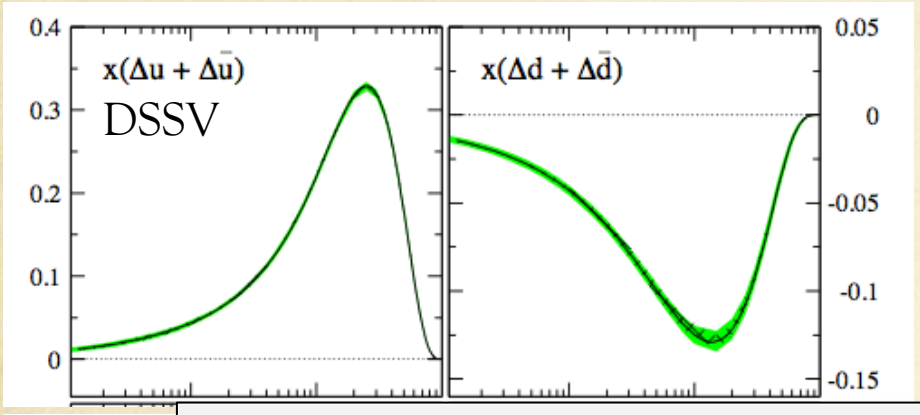

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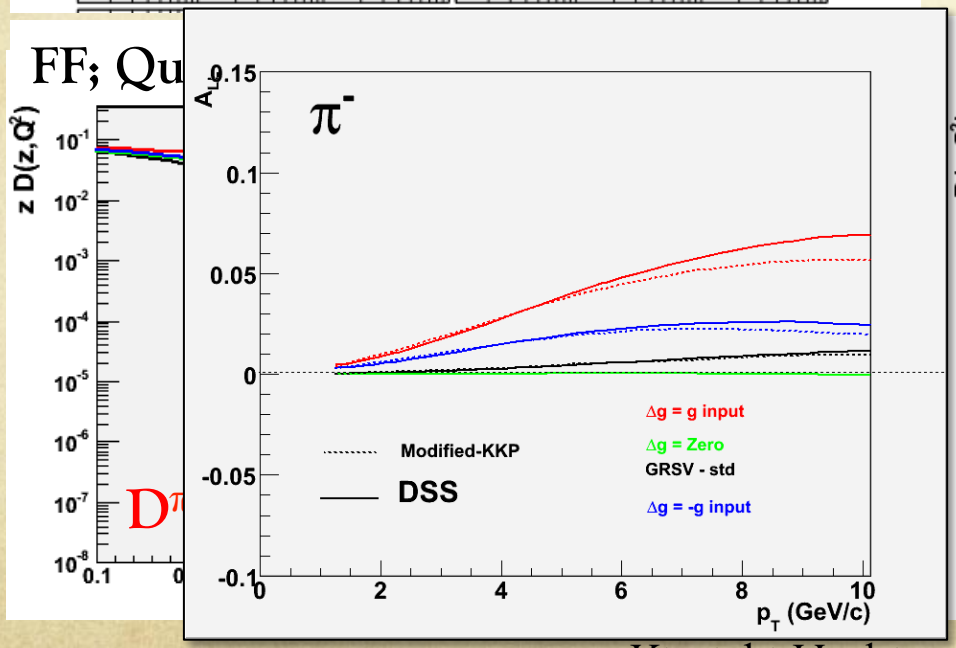
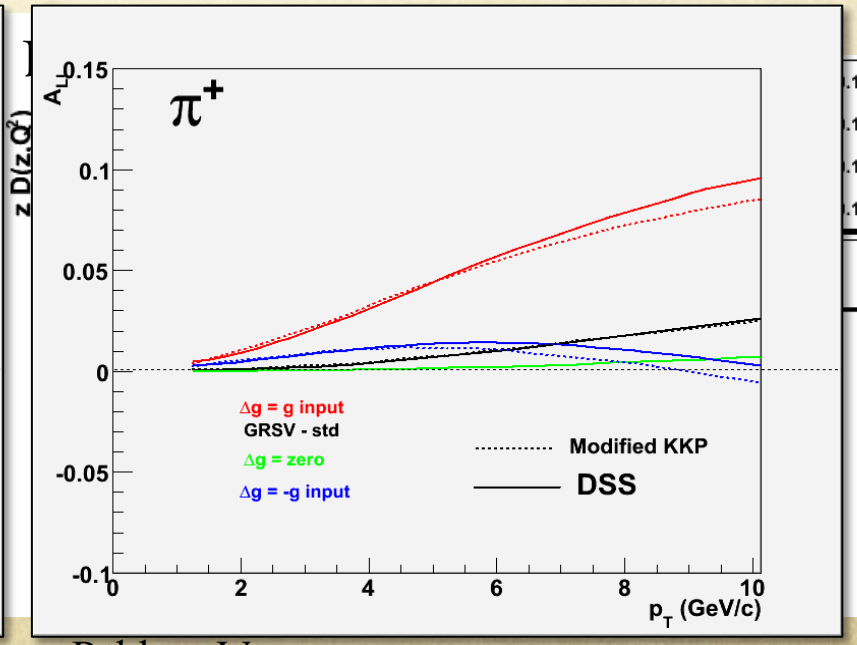
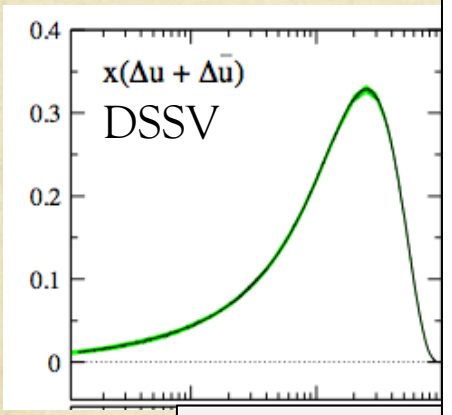
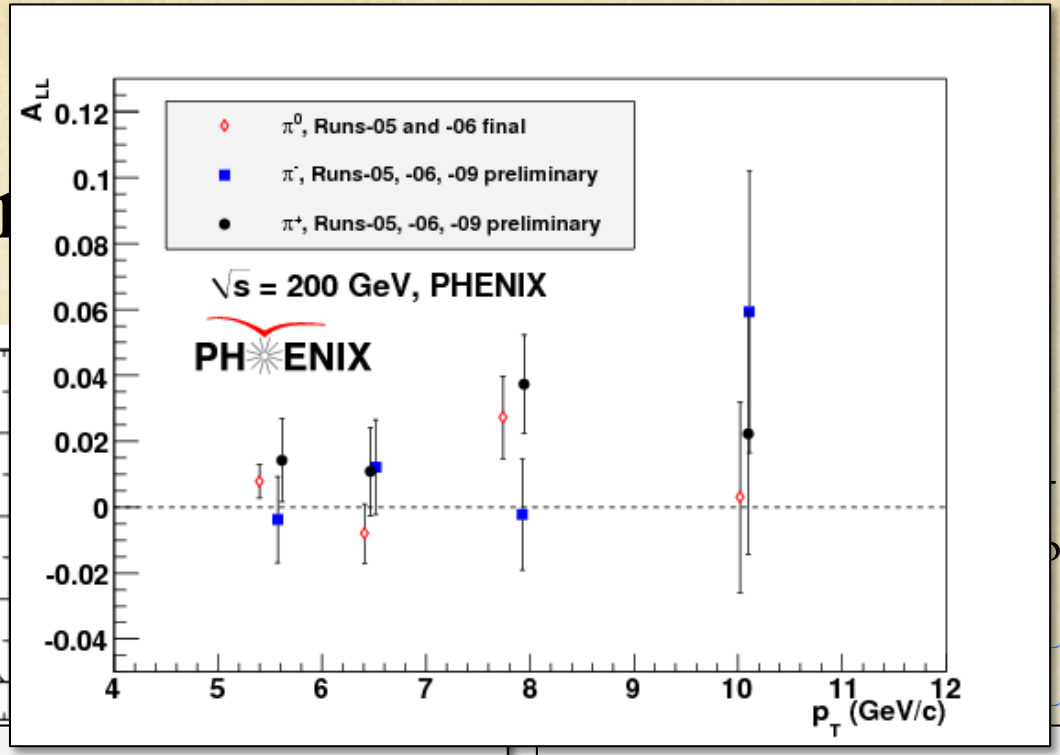




have se… PDF

$d\bar{u}$



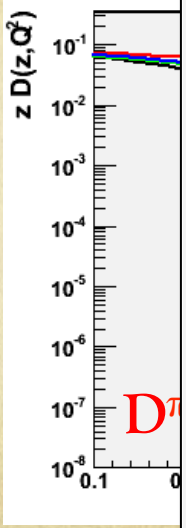


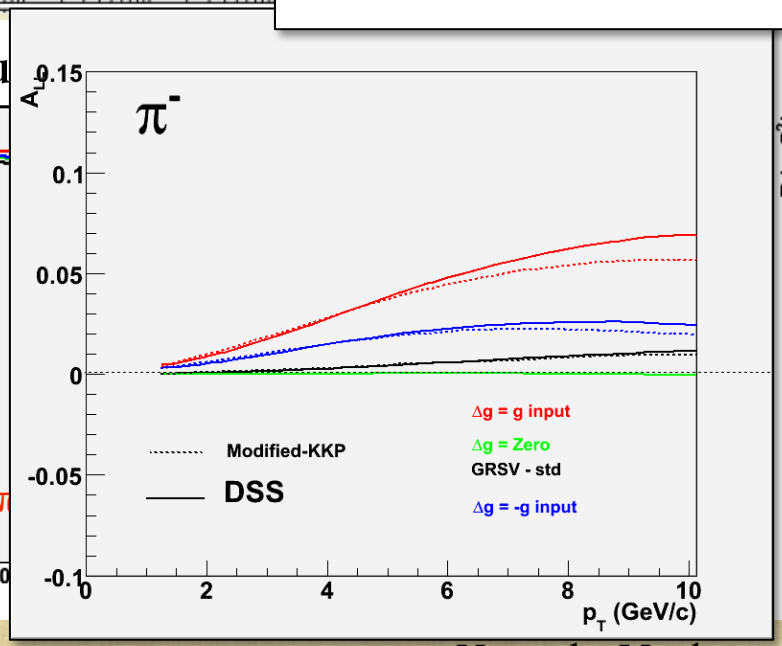
…DF and FFs.

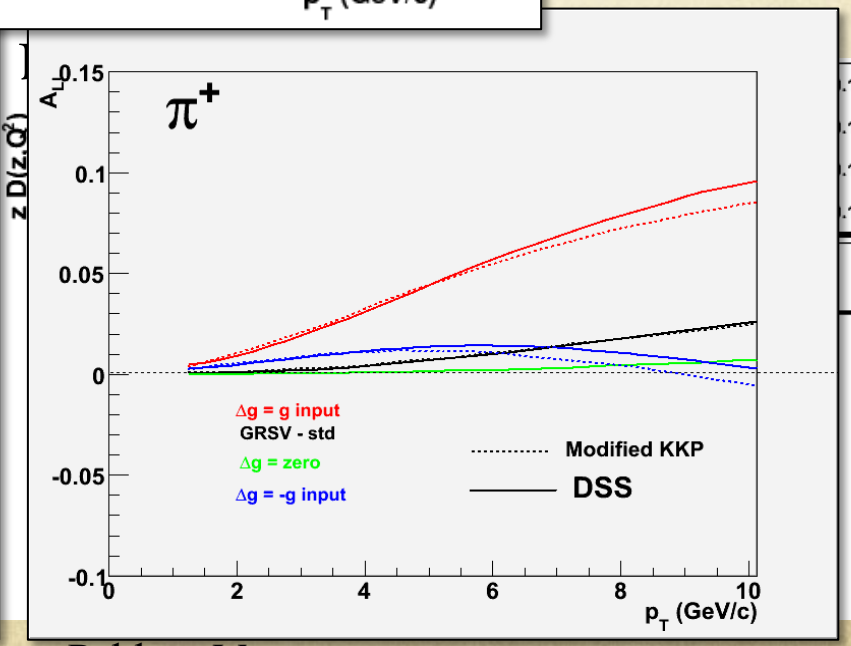
$A_{LL}(\pi^-)$ for $\Delta G>0$

$A_{LL}(\pi^-)$ for $\Delta G<0$

FF; Qu…





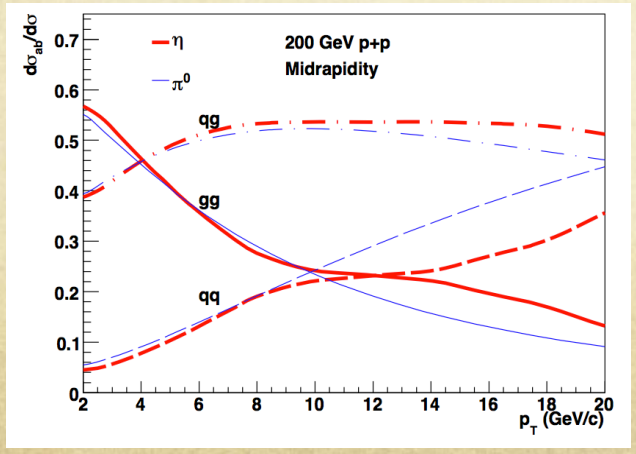


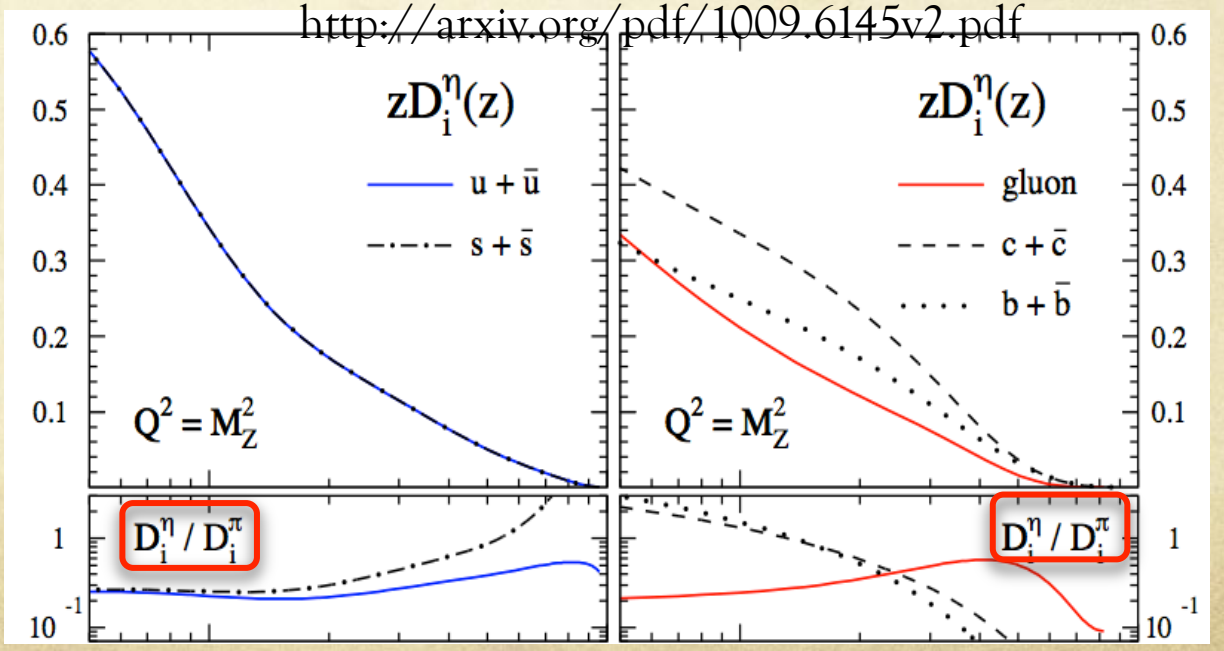
The η meson production; Different FF and statistics.

- We believe A_{LL} for inclusive hadron production is small. η meson A_{LL} become systematic check.
- Different F.F. and different statistics.
- Reconstruct η meson from 2gamma.
- Branching Ratio of η →2gamma ; ~40%.
- Statistics is limited compare with π^0; 10~15% of π^0's statistics

$$\pi^0 = u\bar{u} - d\bar{d}$$
$$\eta = u\bar{u} + d\bar{d} - 2s\bar{s}$$

http://arxiv.org/pdf/1009.6145v2.pdf





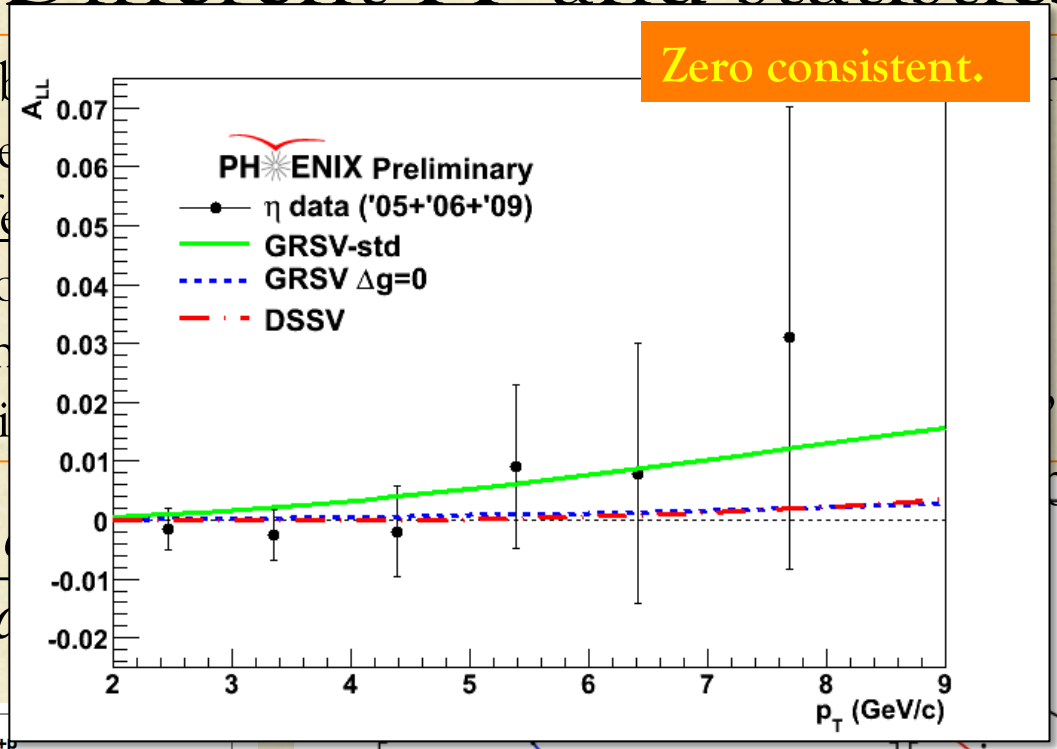
The η meson production; Different FF and statistics.

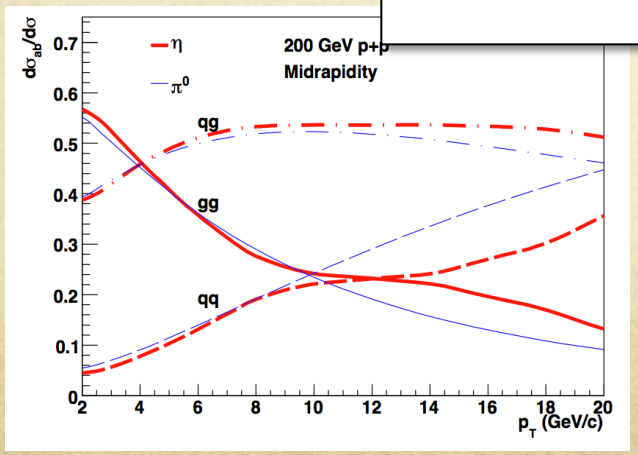
- We k… mall.
  η me…
- Diffe…
- Recc…
- Bran…
- Stati… 's statistics

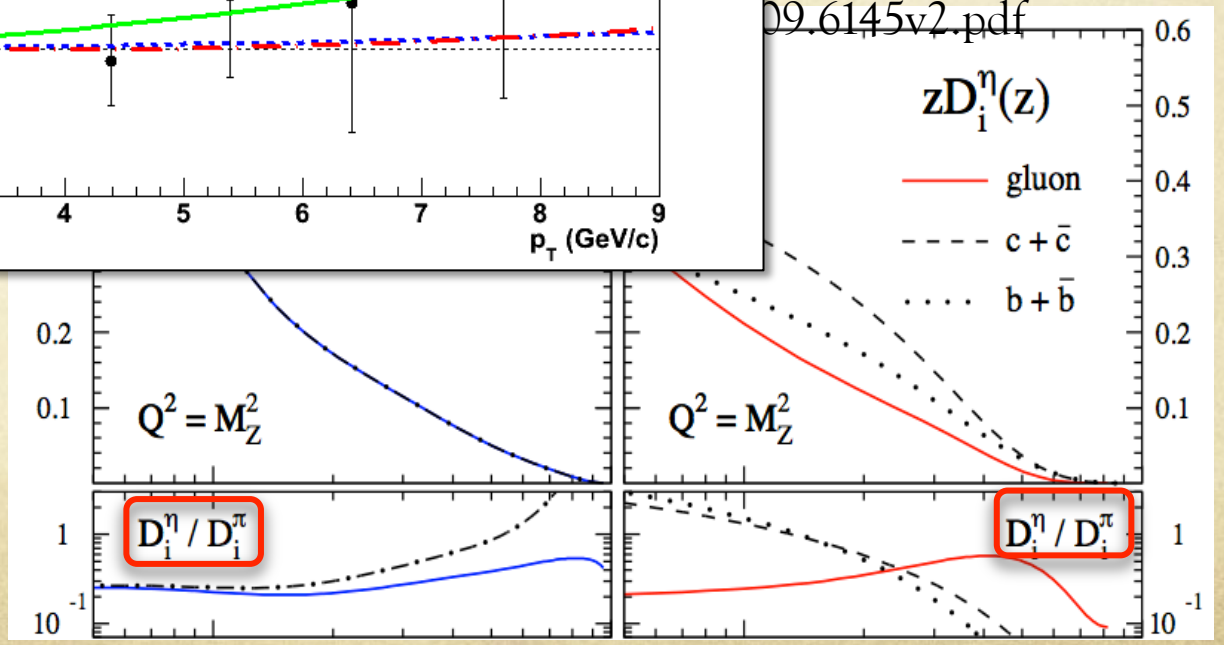
…09.6145v2.pdf

$$\pi^0 = u\bar{u} - \ldots$$
$$\eta = u\bar{u} + d\bar{\ldots}$$

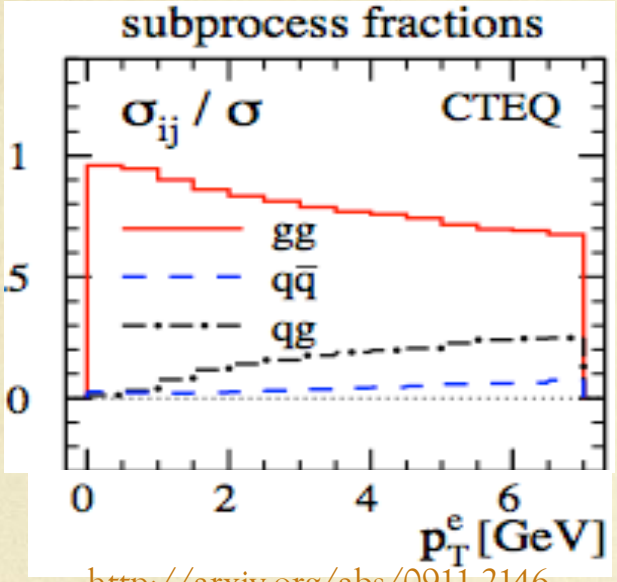
Zero consistent.







The single electron almost exclusively come from g-g scattering



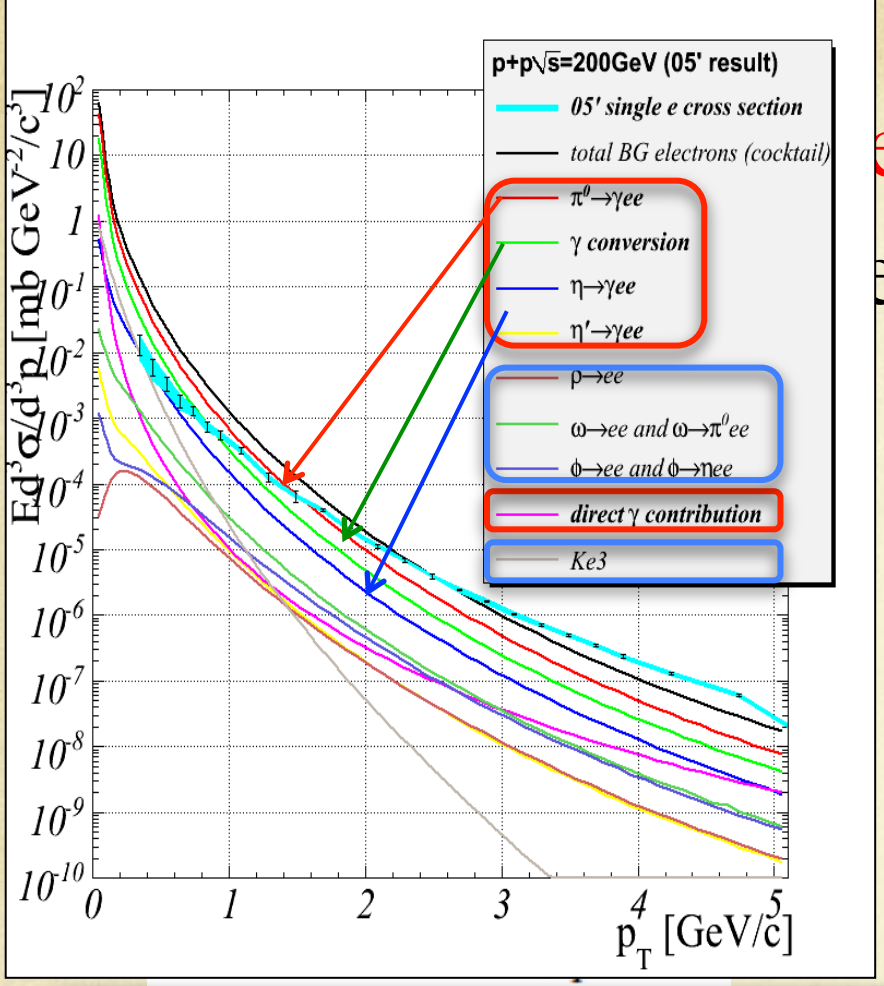
http://arxiv.org/abs/0911.2146

- The electron from heavy meson decay.

$$D^+ \to \overline{K}^0 \nu_e e^+$$
$$D^0 \to K^- \nu_e e^+$$

- g-g scattering is dominant process.
  So, the single e is clean channel for the Δg.

electron almost
e from g-g scattering



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So, the single e is clean channel for the Δg.

The dominant background sources

- photon conversion
  $\pi^0(\eta) \rightarrow \gamma\ \gamma\ \gamma \rightarrow e^+e^-$(in material)
- Dalitz decay
  $\pi^0(\eta) \rightarrow \gamma\ e^+e^-$
- direct photon conversion.

K and vector mesons decay is small at pt>0.5GeV

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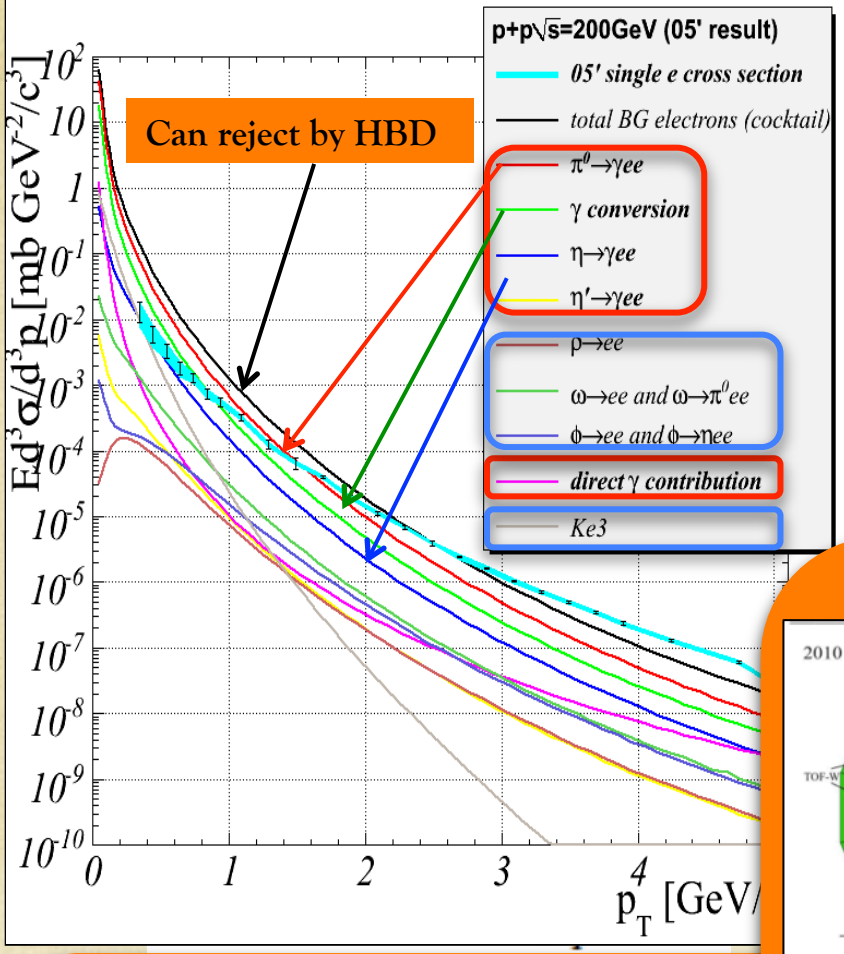

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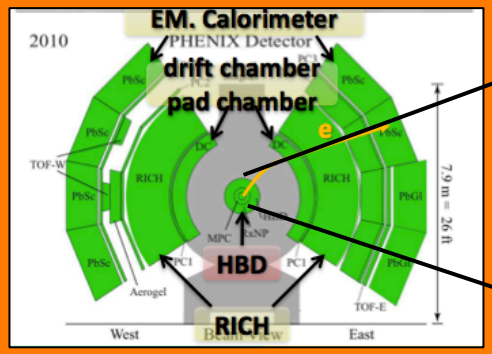

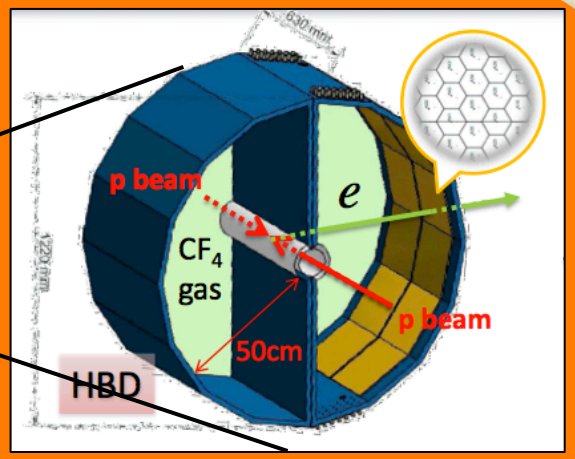

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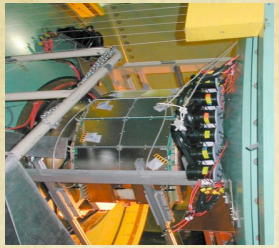
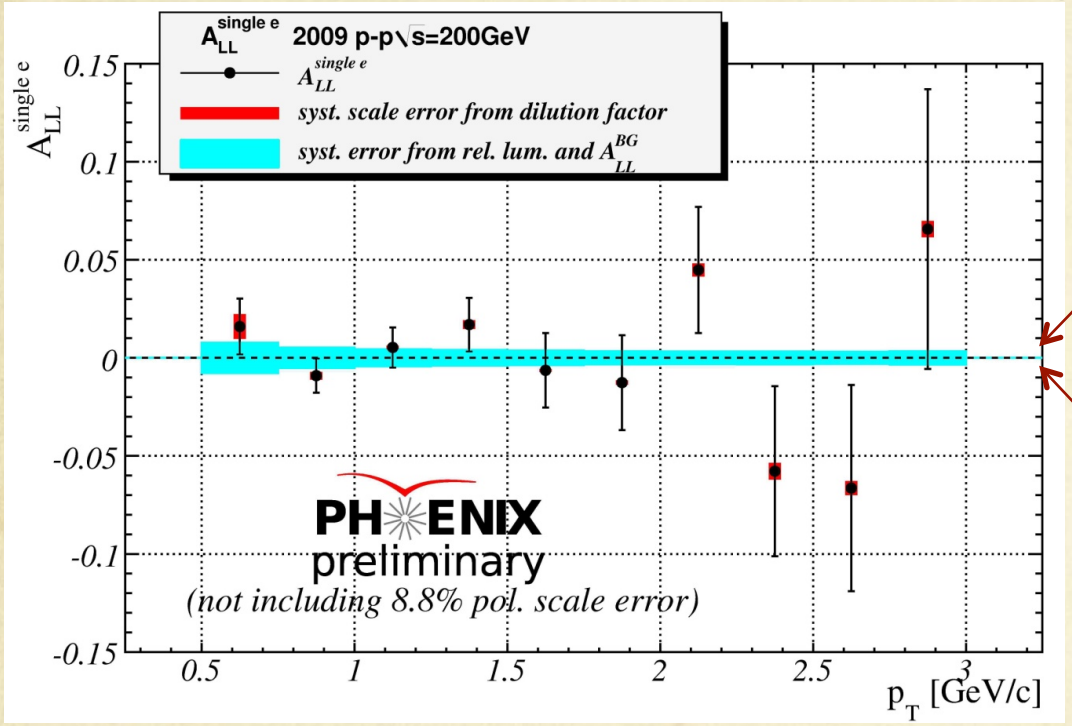
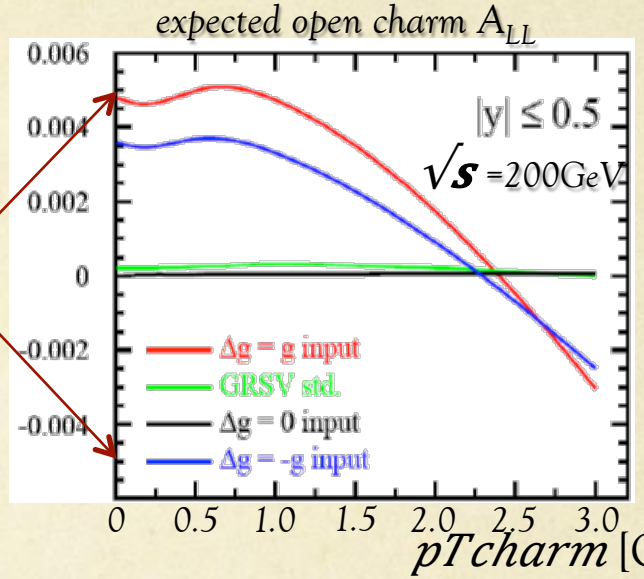
HBD is the gas Cerenkov detector with CsI evaporated GEM.



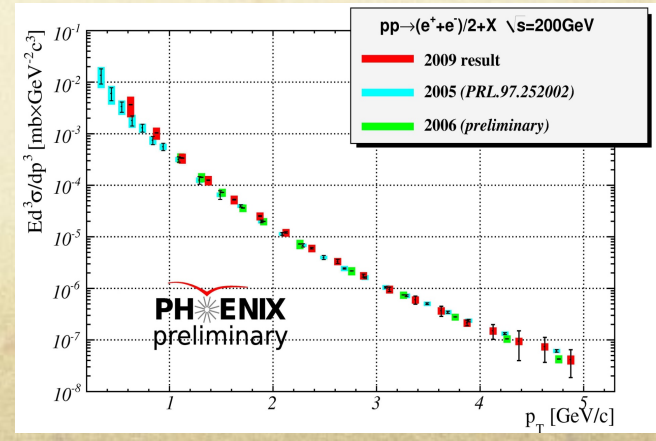
The single electron almost come from g-g scattering



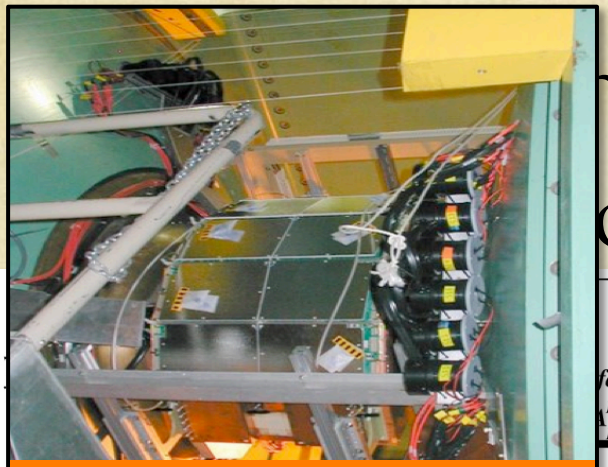


The first time of physics measurement with PHENIX HBD!!

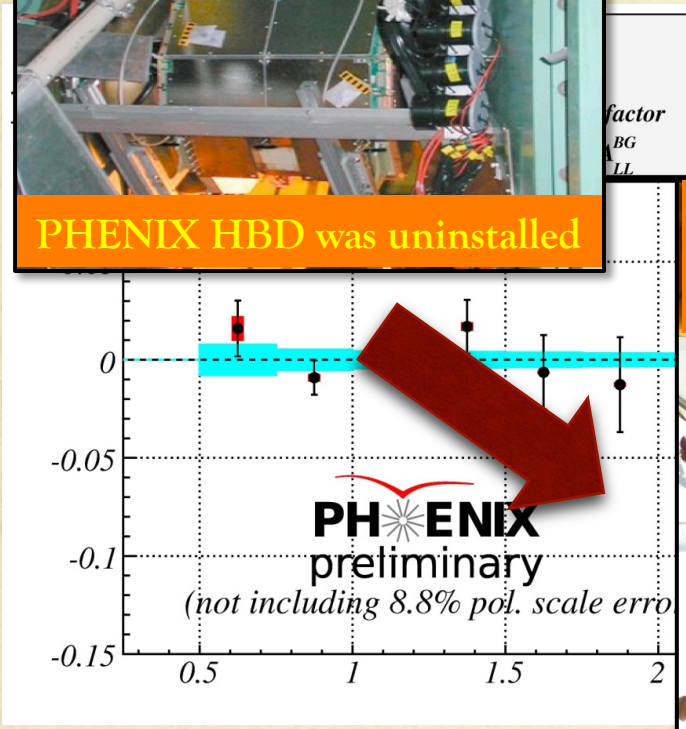
- HBD ; BG rejection for electron.
- RICH ; electron ID.
- DC/PC ; tracking & momentum.
- EMCal ; energy



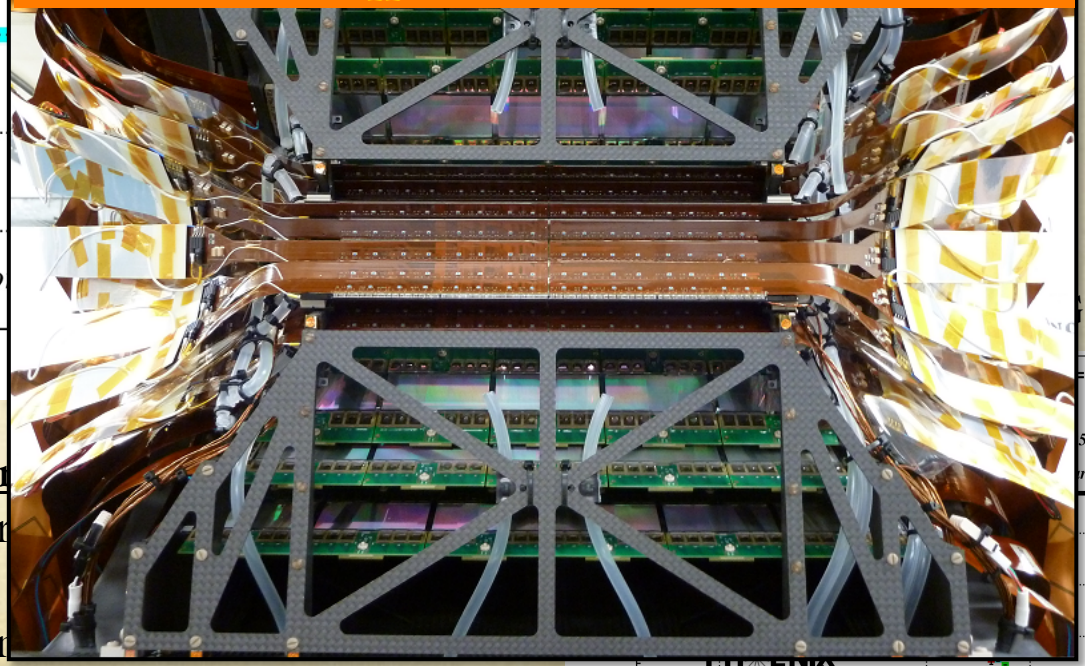
ne single electron
ome from g-g scattering



PHENIX HBD was uninstalled



The subsequent study will be
Single electron A_{LL} with PHENIX VTX !

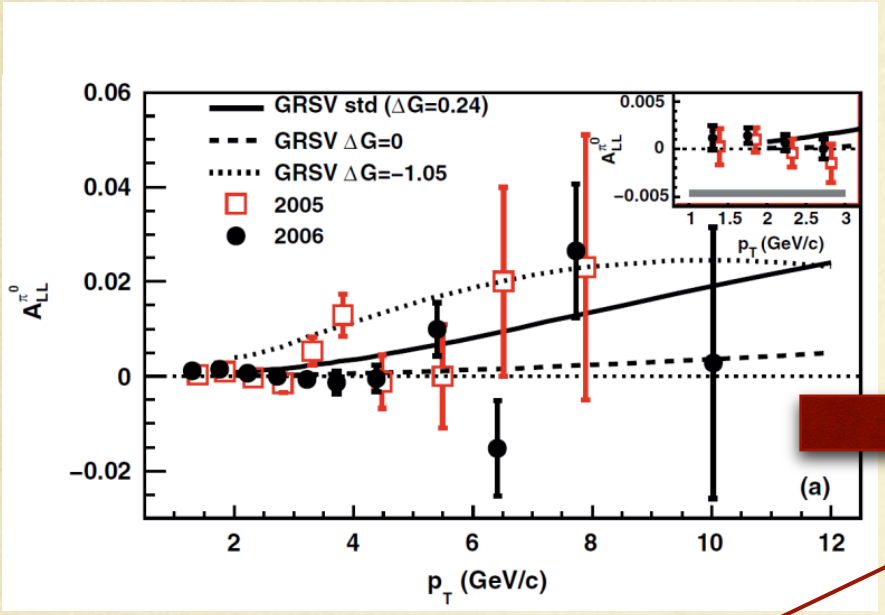


eV/c]

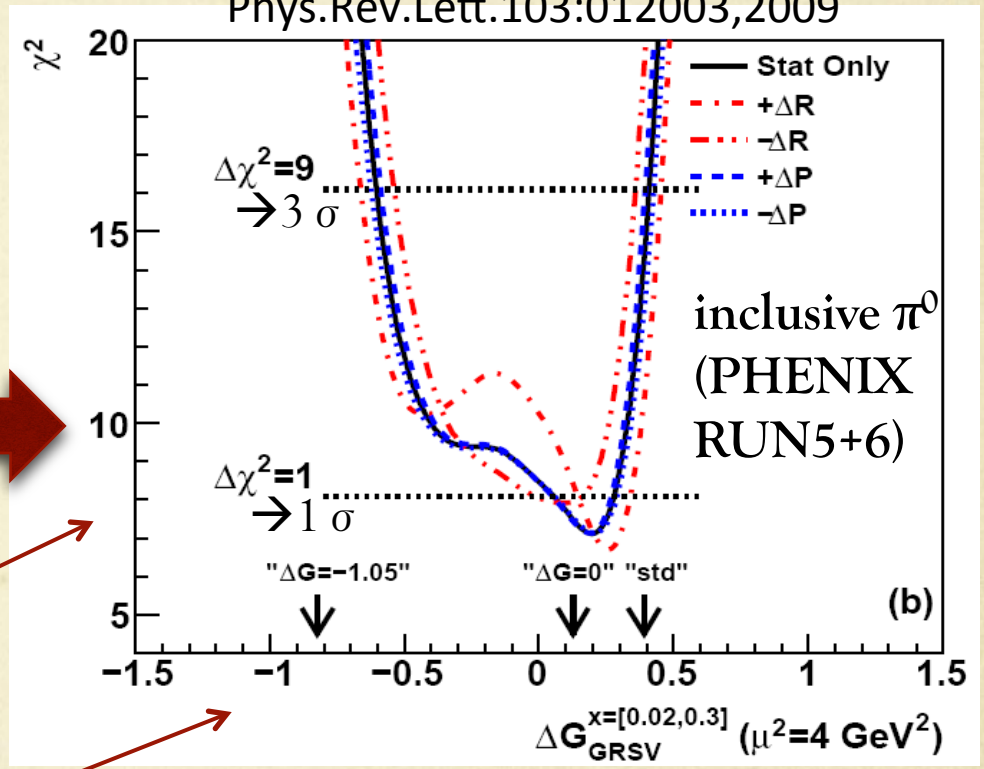
The first time of physics measurer

- HBD ; BG rejection for electr
- RICH ; electron ID.
- DC/PC ; tracking & momentu
- EMCal ; energy

Current constrain on ΔG



Phys.Rev.Lett.103:012003,2009



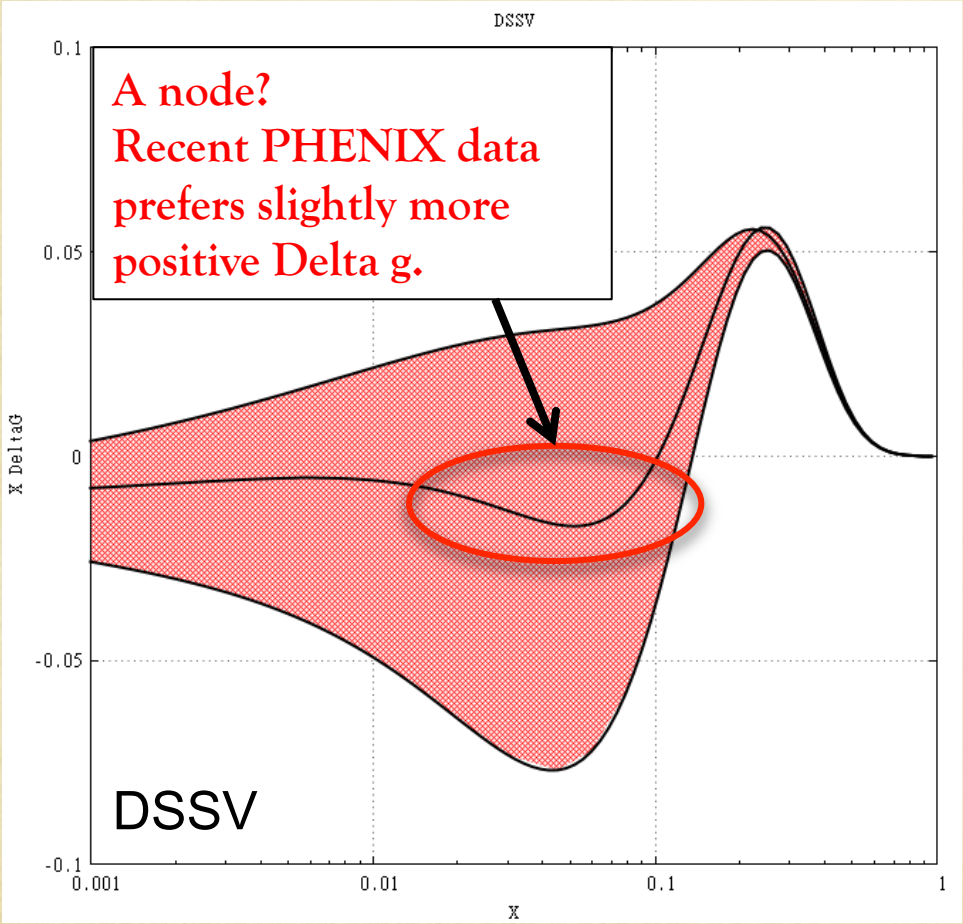
$$\chi^2 = \sum_{p_T\ bins} \frac{\left(A_{LL}^{data} - A_{LL}^{theory}\right)^2}{\sigma_{stat}^2}$$

Integrate gluon PDF(GRSV) over proved x range, [0.02,0.3]

Stat.error: $\Delta G_{GRSV}^{x=[0.02,0.3]}\left(\mu^2 = 4GeV^2\right)$

$= 0.2 \pm 0.1\,(1\sigma)$ and $0.2^{+0.2}_{-0.8}$ (3σ)

Global Fitting result of Δ g with RHIC Data(Not PHENIX analysis)



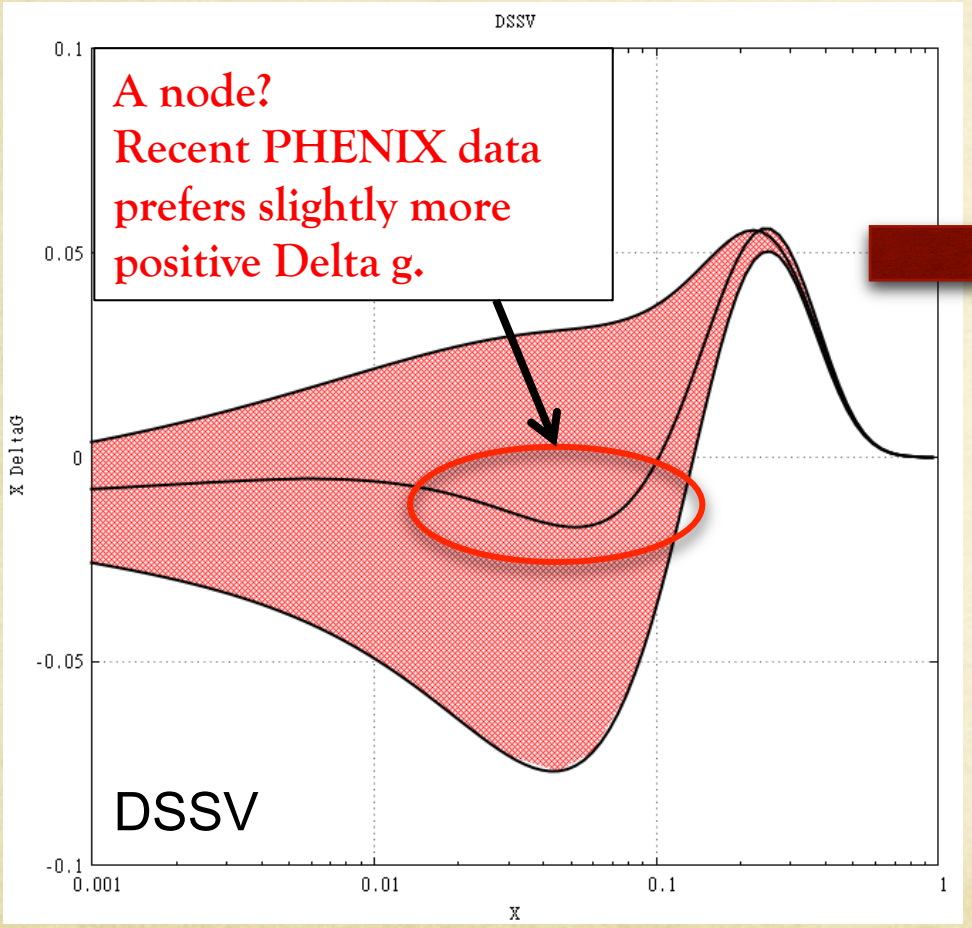
Data set.

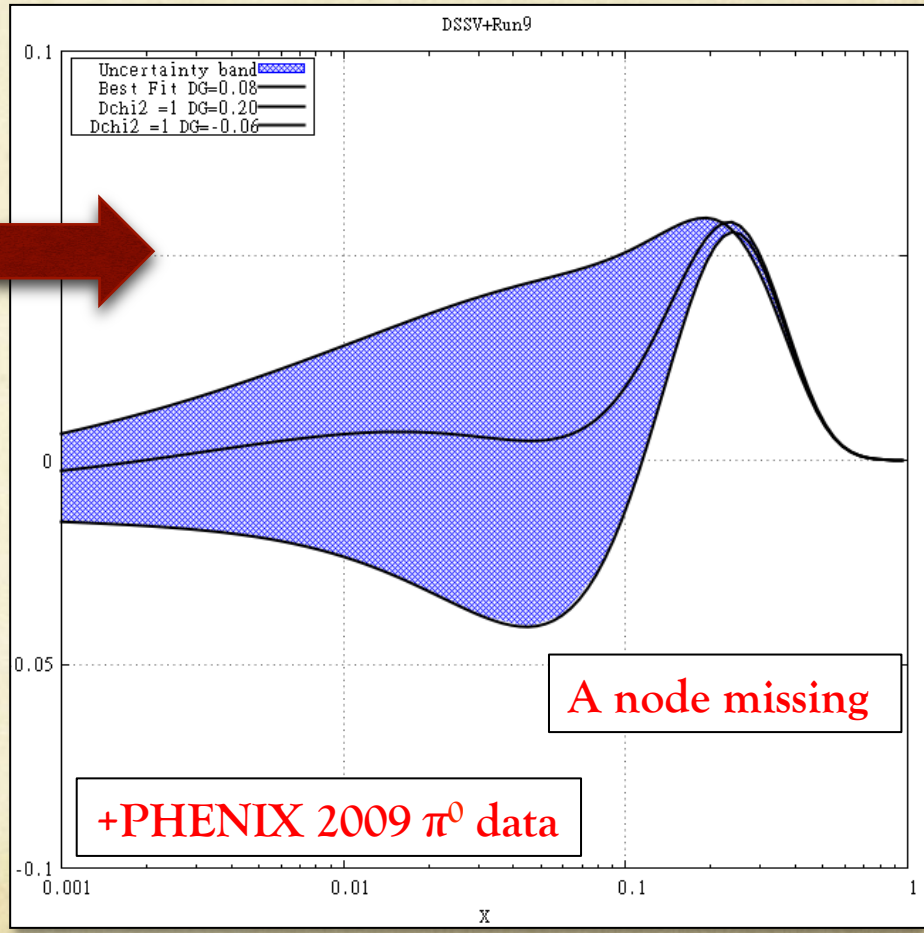
experiment	data type	data point fitted
EMC, SMC	DIS	34
COMPASS	DIS	15
E142, E143, E154, E155	DIS	123
HERMES	DIS	39
HALL-A	DIS	3
CLAS	DIS	20
SMC	SIDIS, $h^{\pm}$	48
HERMES	SIDIS, $h^{\pm}$	54
	SIDIS, $\pi^{\pm}$	36
	SIDIS, $K^{\pm}$	27
COMPASS	SIDIS, $h^{\pm}$	24
PHENIX (in part prel.)	200 GeV pp, π^0	20
PHENIX (prel.)	62 GeV pp, π^0	5
STAR (in part prel.)	200 GeV pp, jet	19
TOTAL:		467

(Phys.Rev.D80:034030,2009.)

S. Taneja DIS 2011 Workshop

Global Fitting result of Δ g with RHIC Data(Not PHENIX analysis)

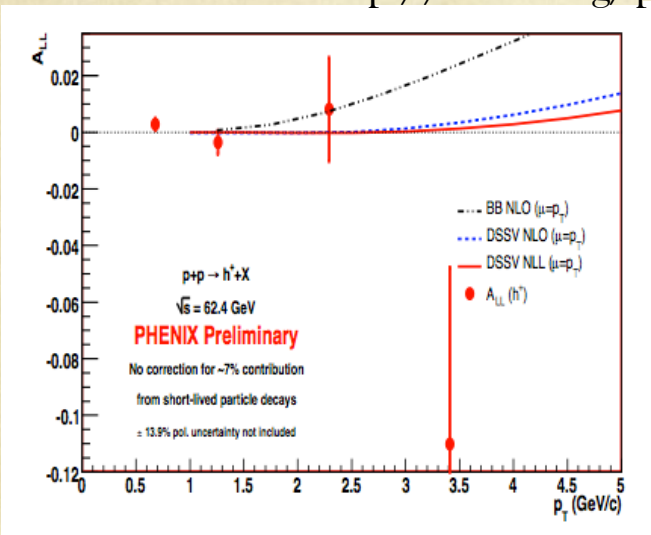


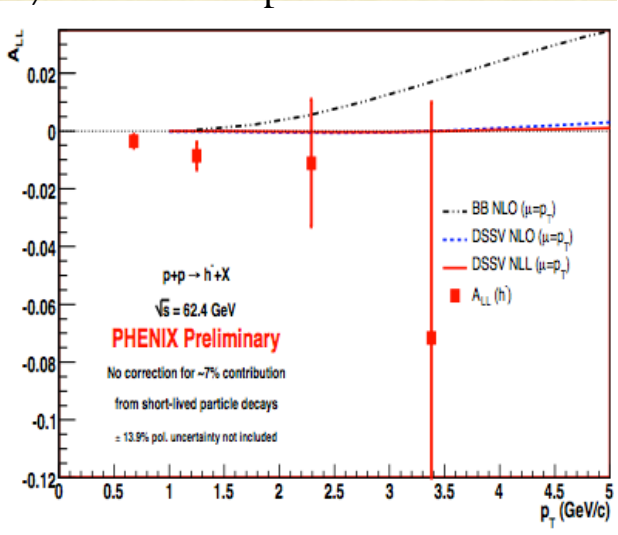


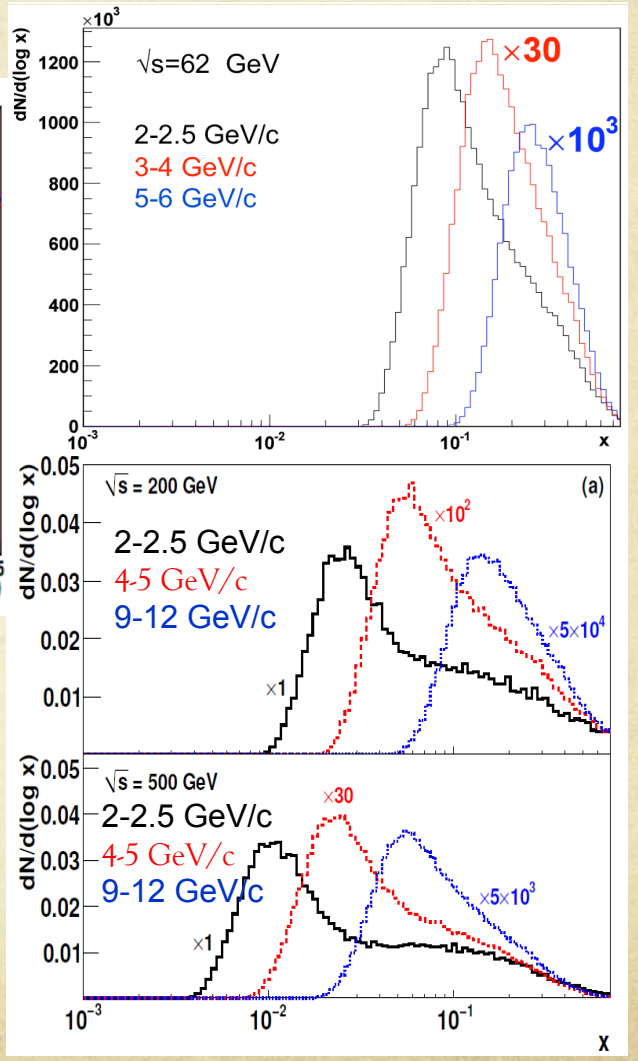
S. Taneja DIS 2011 Workshop

The low energy collisions can access higher Bjorken-x region

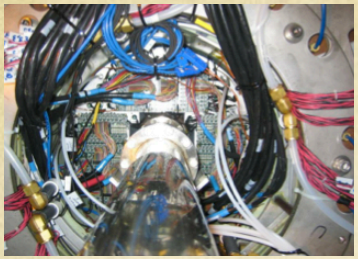
http://arxiv.org/pdf/1101.0802.pdf



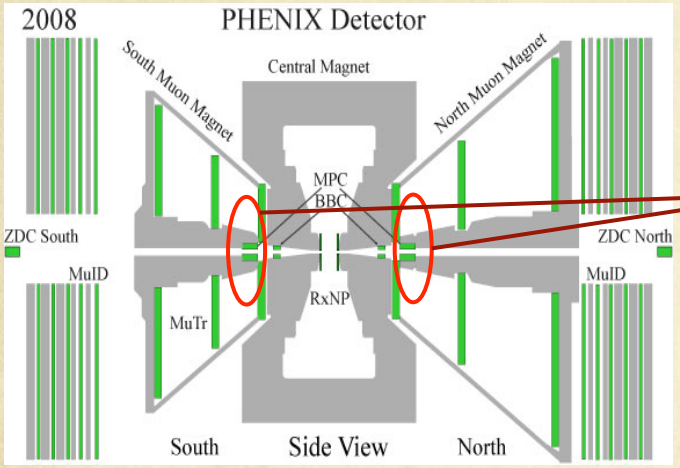




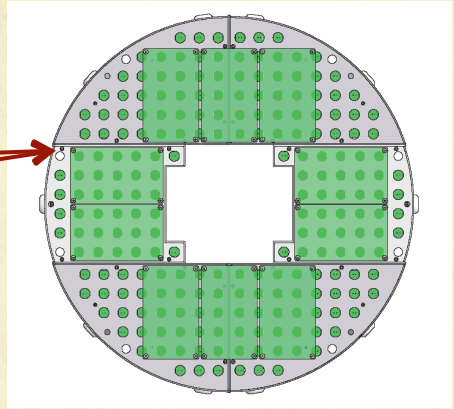
- RUN06 data ; 15.6nb^{-1}, $\langle P_{B,Y} \rangle$=48%
- Unidentified hadron(π,K,p etc)
- Tracking ; DC+PC
- RICH was used for rejecting background from electrons.



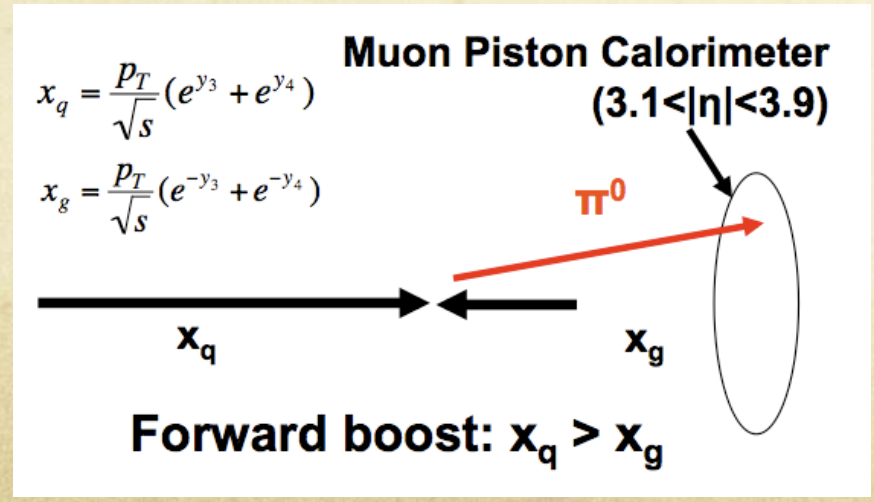
The MPC Cluster can access lower Bjorken-x region

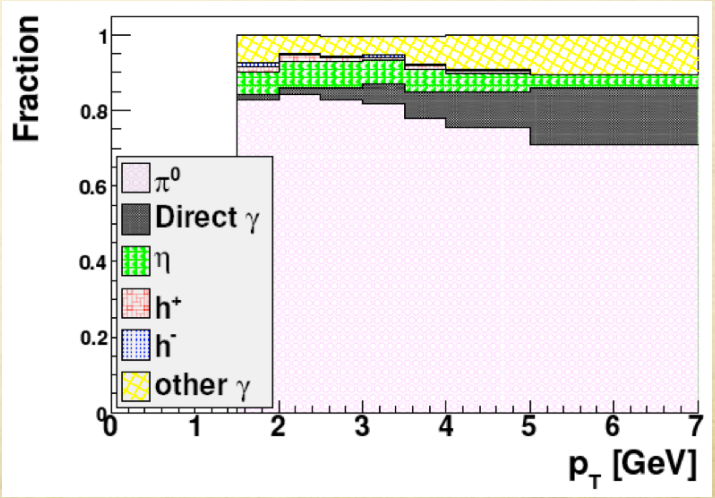


Cross section of MPC

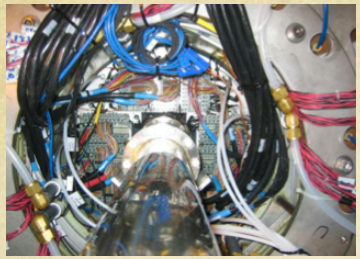


- Array of $PbWO_4$ crystals modeles.
- 412 crystals.
- Higher energy 2gamma from π^0 merge E_{pi0} > 20 GeV(Pt_{pi0}>2 GeV)
- MPC can access low x ; x ~ 10^{-3}



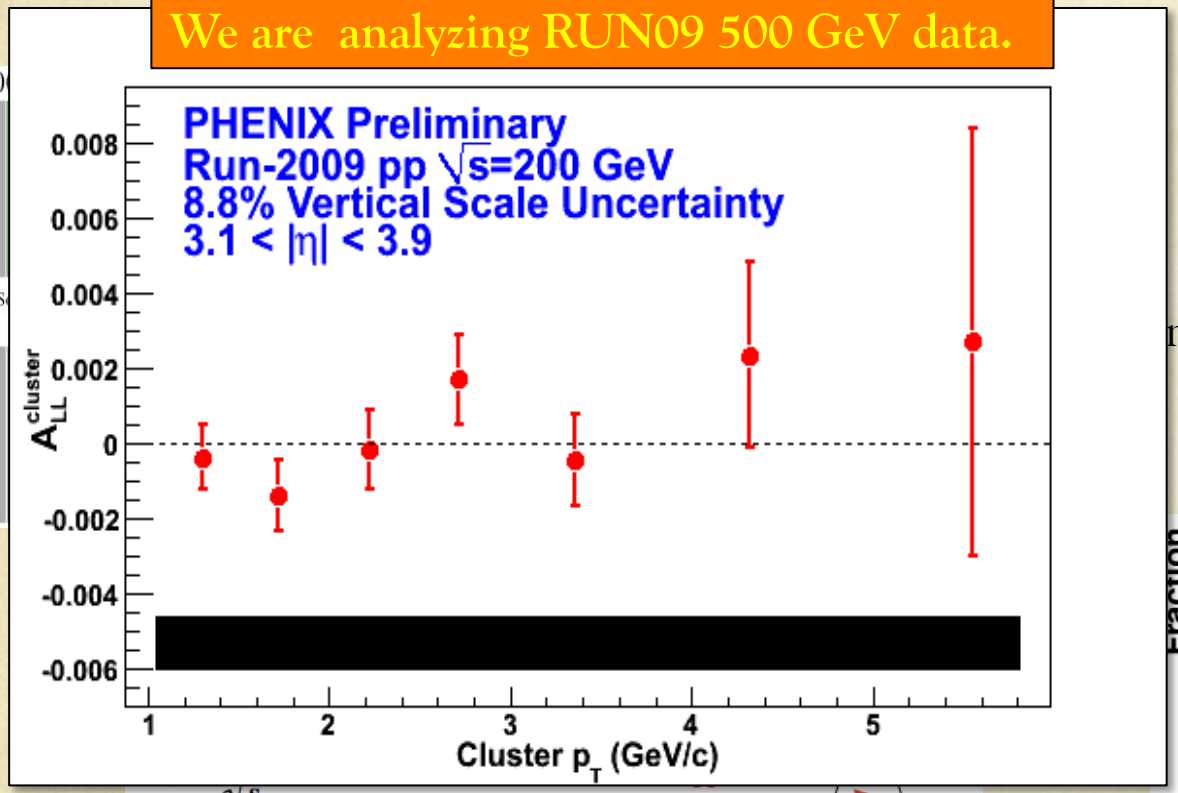


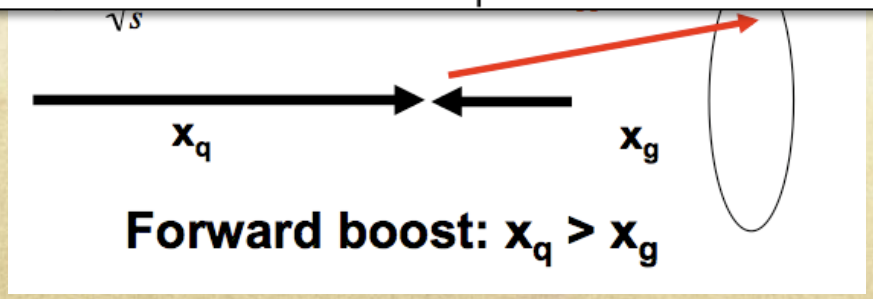
J.Koster's D-thesis



The MPC Cluster can access lower Bjorken-x region

We are analyzing RUN09 500 GeV data.





- Array of $PbWO_4$ crystals modeles.
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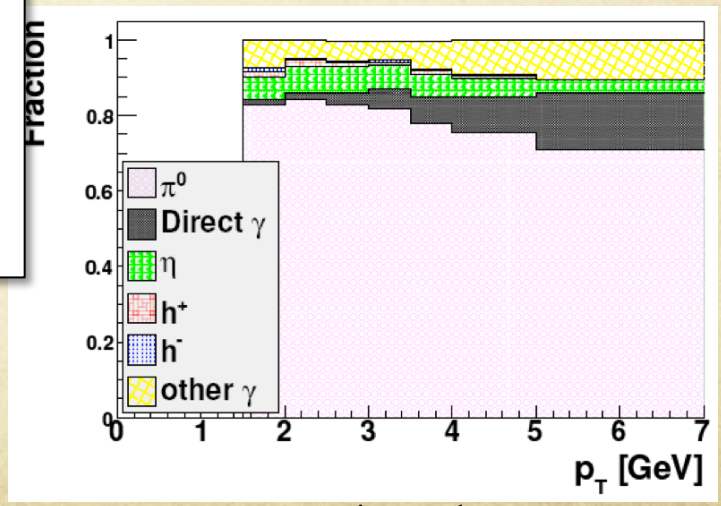
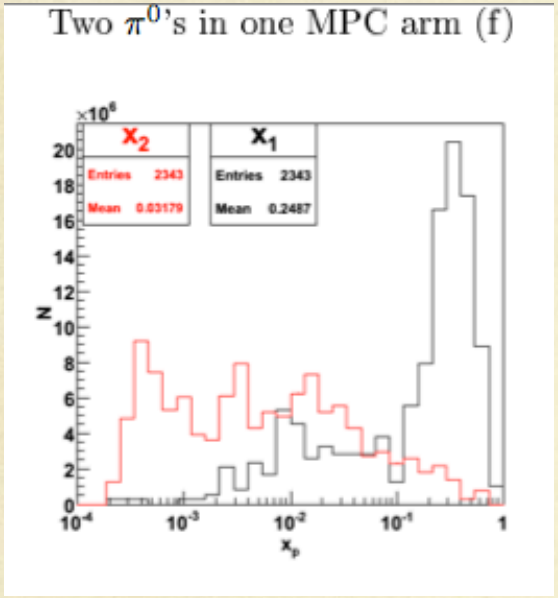
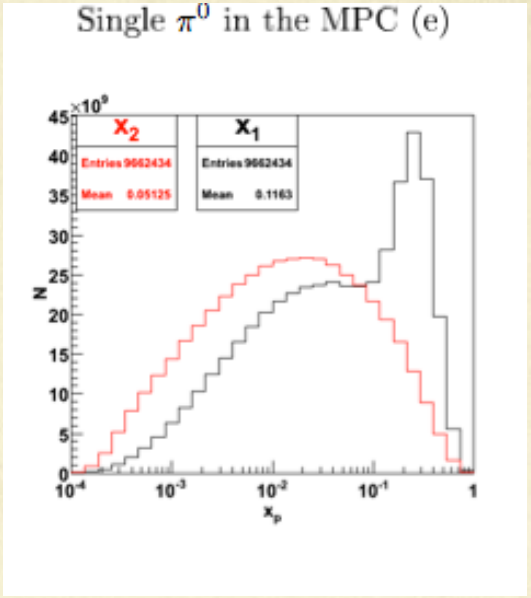


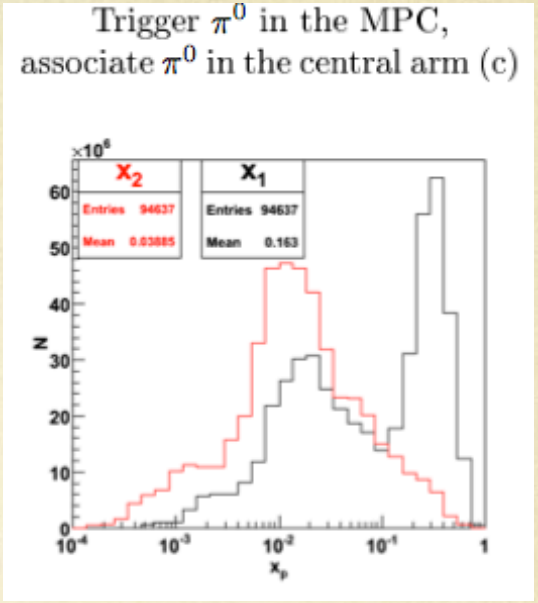
J.Koster's D-thesis

Projection for MPC Clusters correlation and MPC-Central arm correlation@ 500 GeV

https://www.phenix.bnl.gov/phenix/WWW/p/info/an/1005/pythia_lowx_ALL.pdf

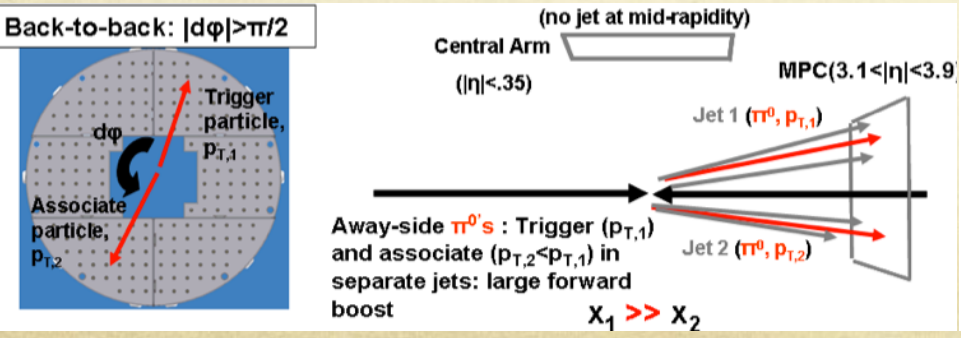


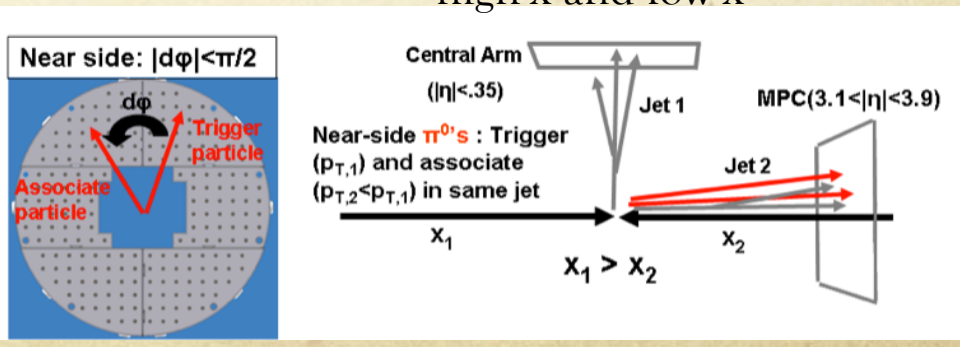




Reduce contribution from high-x.

Reduce contribution from high-x and low-x

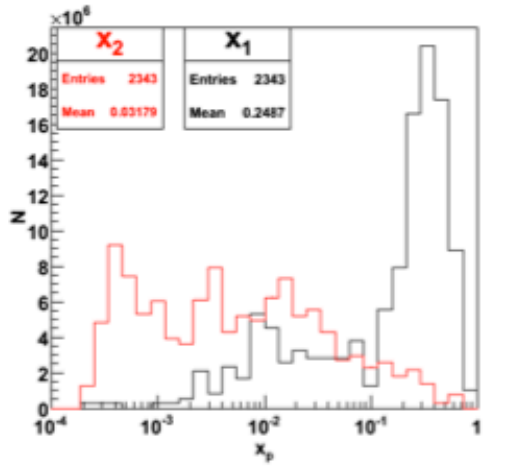




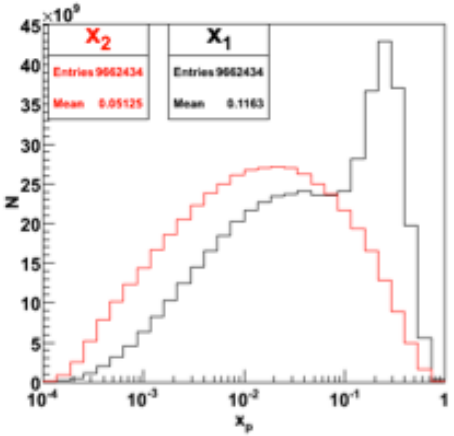
Projection for MPC Clusters correlation and MPC-Central arm correlation@ 500 GeV

https://www.phenix.bnl.gov/phenix/WWW/p/info/an/1005/pythia_lowx_ALL.pdf

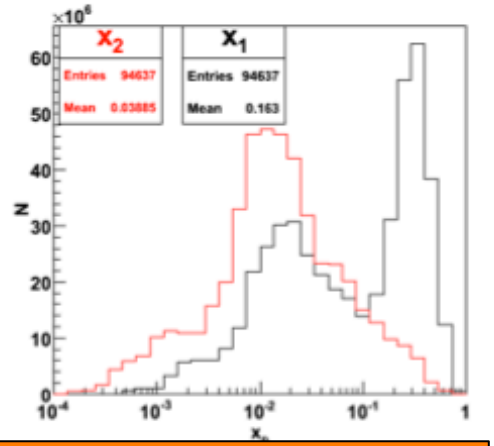
Two π^0's in one MPC arm (f)



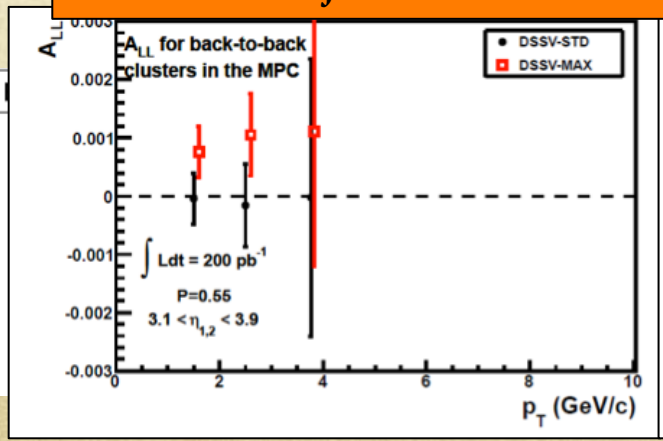
Single π^0 in the MPC (e)

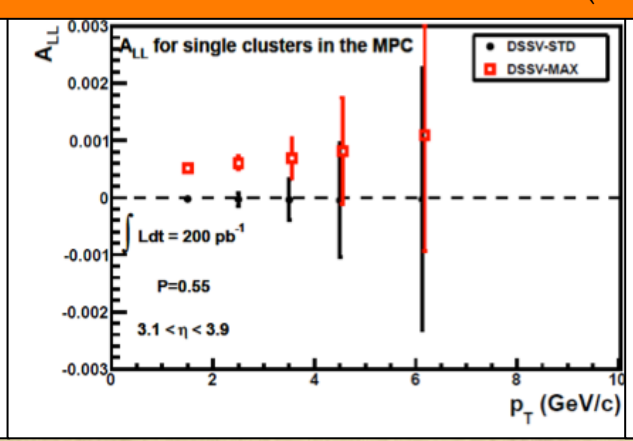


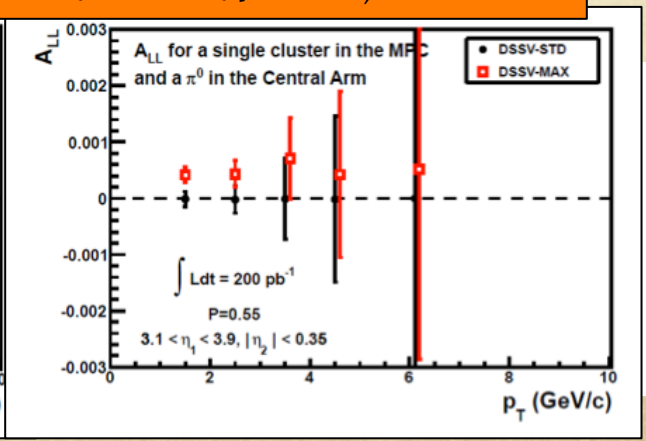
Trigger π^0 in the MPC, associate π^0 in the central arm (c)



Projections for correlation measurements for ΔG (Run13 and 14 BUP).



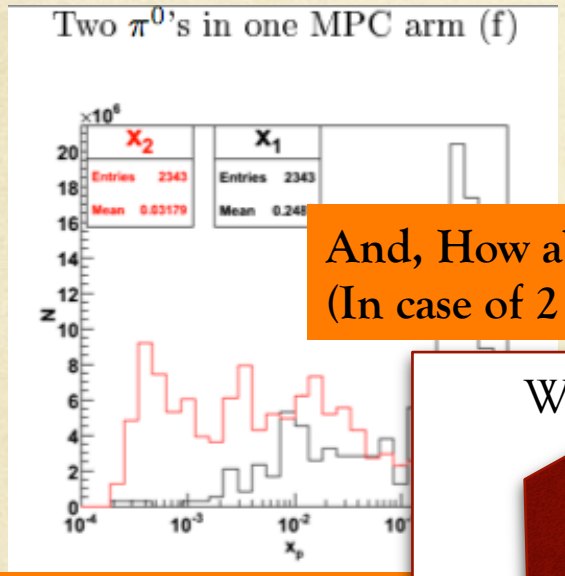


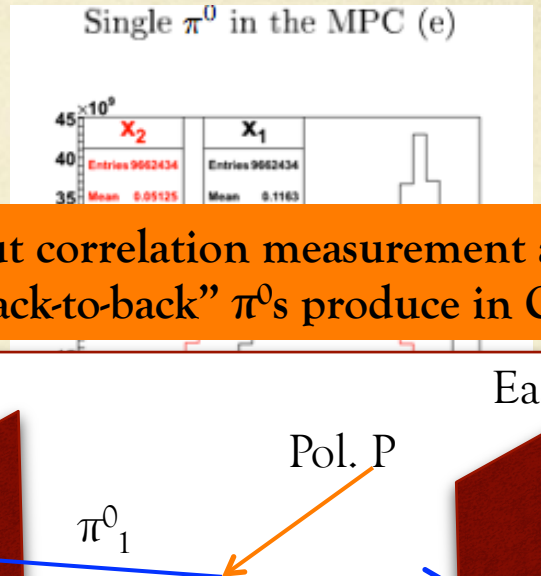


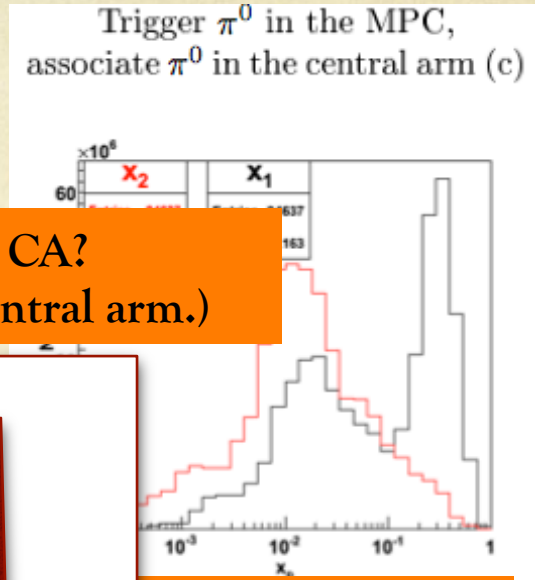
http://www.bnl.gov/npp/docs/PAC0612/PHENIX_BUP2012_r1.pdf

Projection for MPC Clusters correlation and MPC-Central arm correlation@ 500 GeV

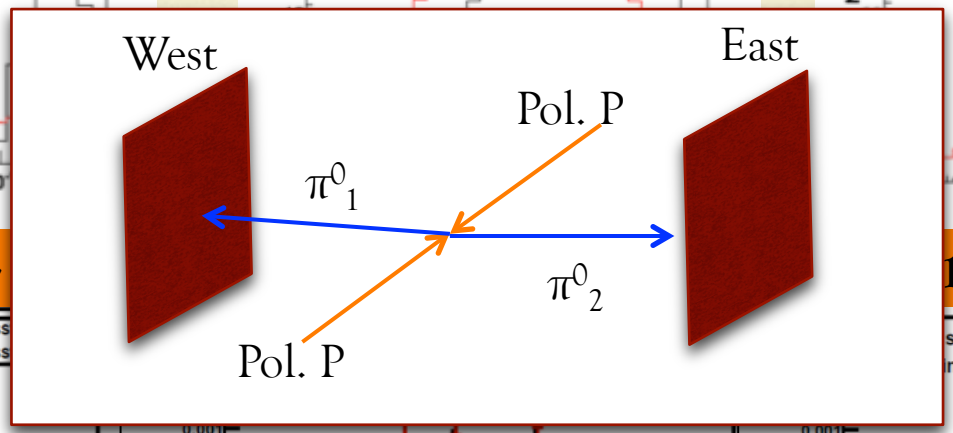
https://www.phenix.bnl.gov/phenix/WWW/p/info/an/1005/pythia_lowx_ALL.pdf



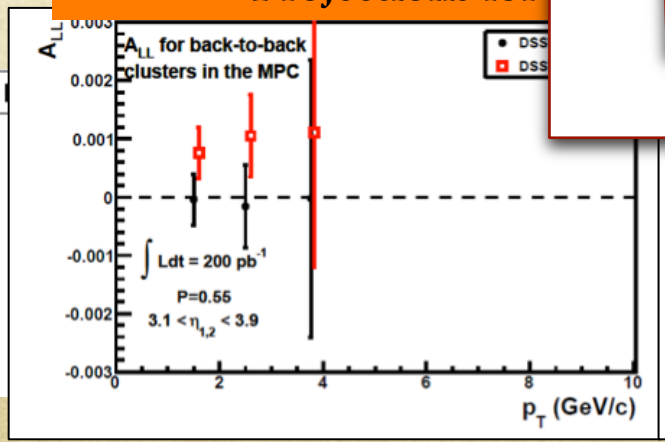


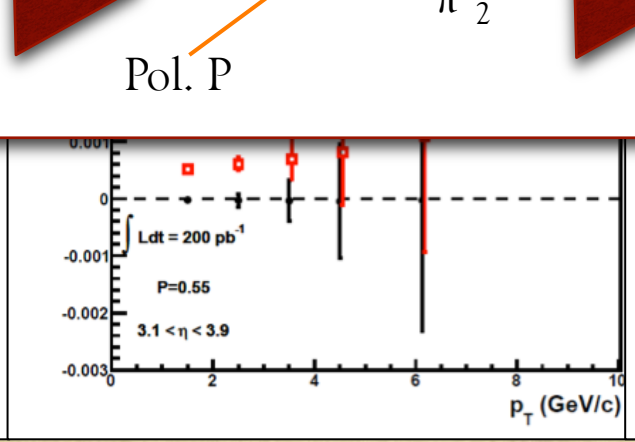


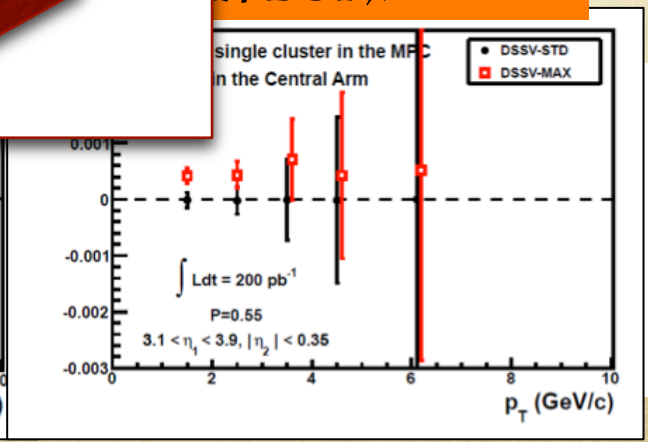
And, How about correlation measurement at CA?
(In case of 2 "back-to-back" π^0s produce in Central arm.)



Projections for **14 BUP).**





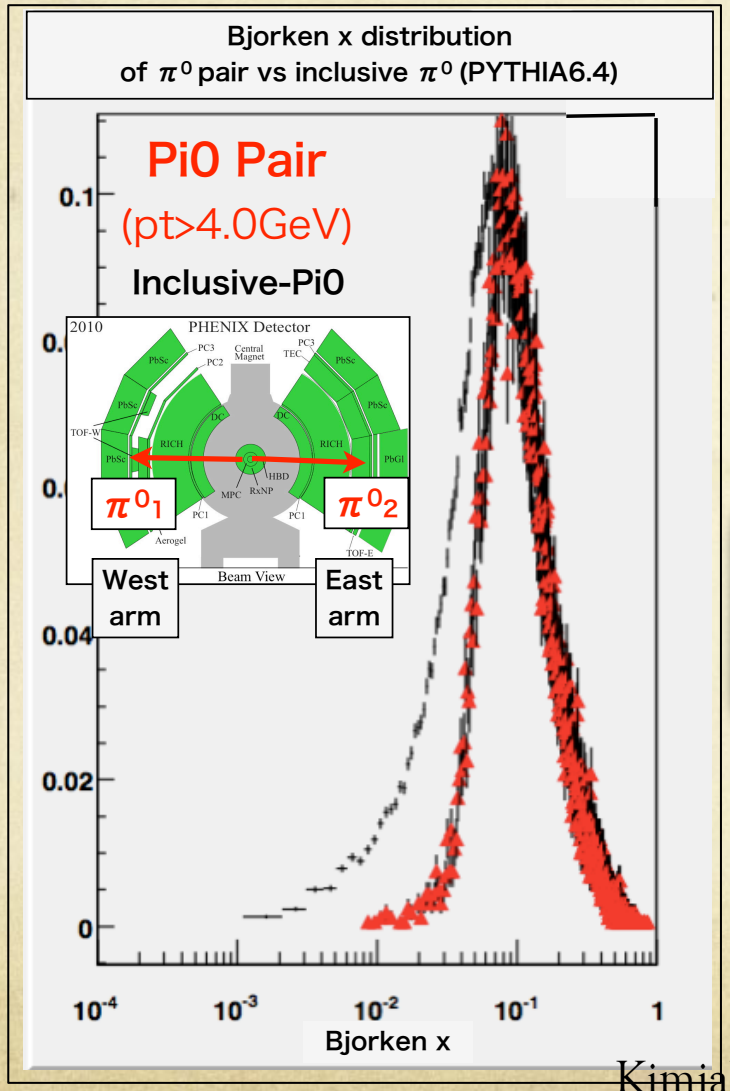


http://www.bnl.gov/npp/docs/PAC0612/PHENIX_BUP2012_r1.pdf

NEW channel for A_{LL} in PHENIX

Di-π^0 Production.

Di-Pi0 production can reduce low-x events



- Measure "Back-to-Back" π^0s which is produced in PHENIX Central Arm.
- This channel can reduce contribution from low-x partons.
- This measurement is first time in PHENIX.

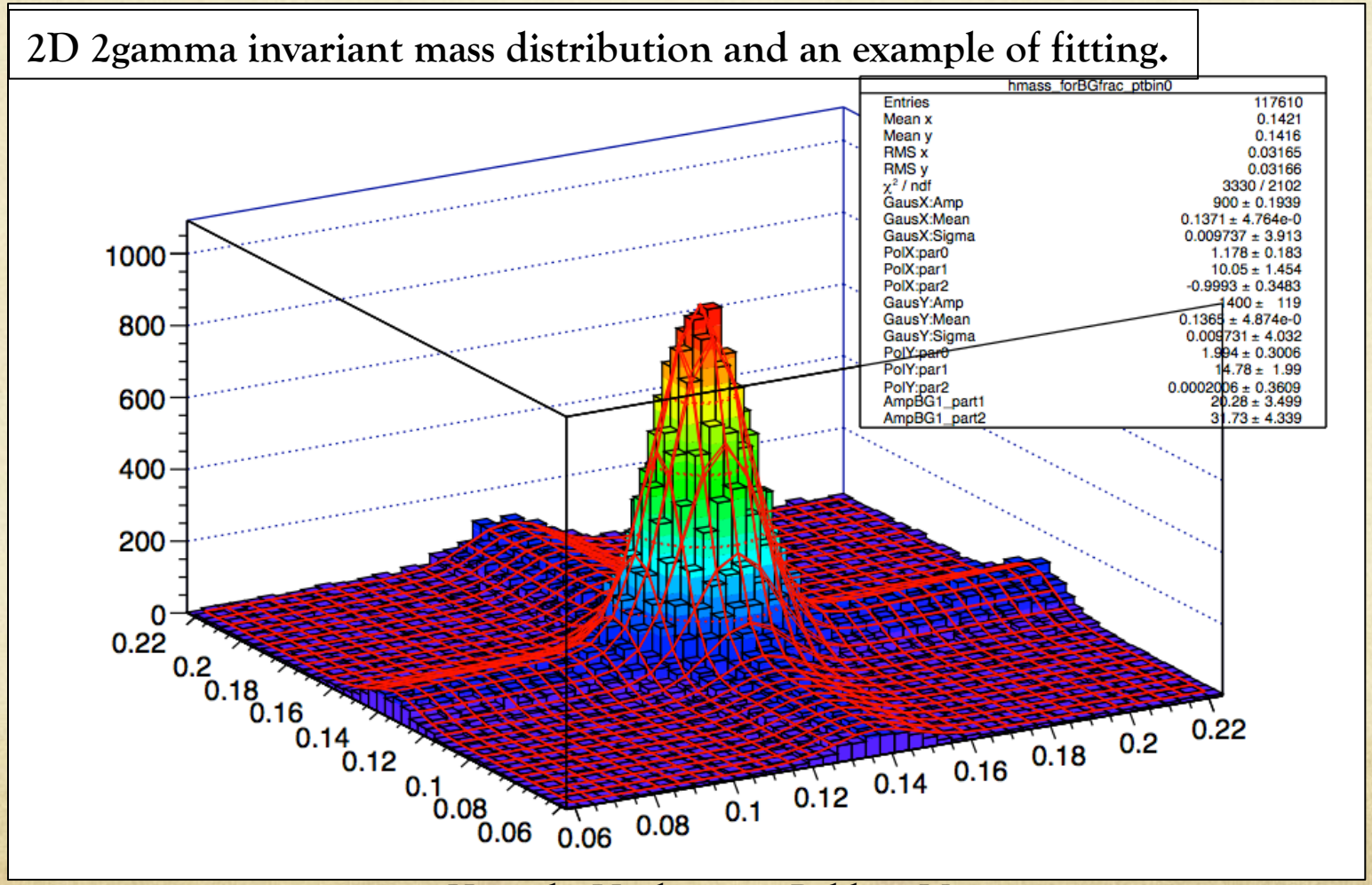
The points in analysis.

- 2 types of background asymmetries exist.
  ➔ We need to subtract 2 background A_{LL}s

We can understand the structure of 2D spectrum from the fitting.

Fitting function➔ $\int_x \int_y (Gaussian_x + polynomial_x)(Gaussian_x + polynomial_y)dxdy$

2D 2gamma invariant mass distribution and an example of fitting.



Fitting function can write down combination of 3 terms.

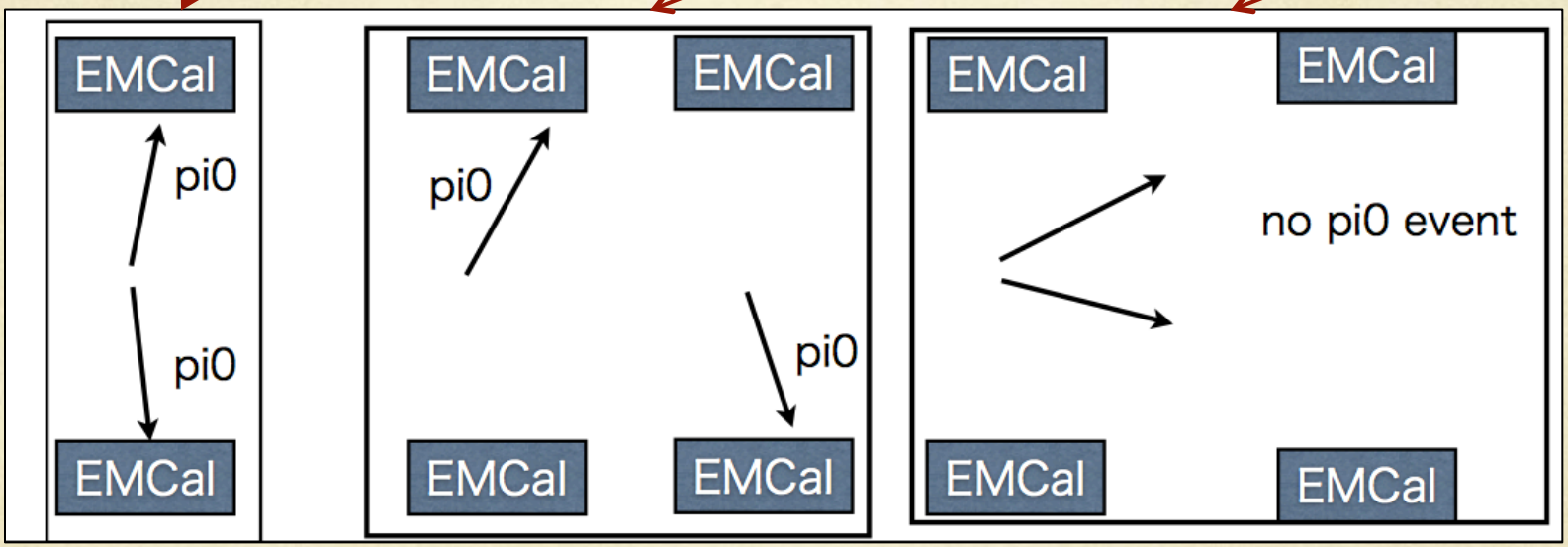
$$\int_x \int_y (Gaussian_x + polynomial_x)(Gaussian_x + polynomial_y) dxdy$$

$$= \int\int dxdy Gauss_x Gauss_y + \int\int dxdy (Gauss_x pol_y + Gauss_y pol_x) + \int\int dxdy (pol_x pol_y)$$

Each terms correspond to Signal and Backgrounds

$$\int_x \int_y (Gaussian_x + polynomial_x)(Gaussian_x + polynomial_y)dxdy$$

$$= \int\int dxdy Gauss_x Gauss_y + \int\int dxdy(Gauss_x pol_y + Gauss_y pol_x) + \int\int dxdy(pol_x pol_y)$$



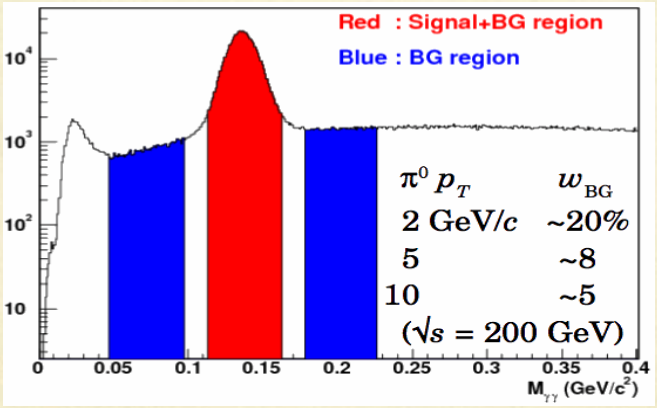
Inclusive π^0 A_{LL} have just one background.

Well known formula for subtracting background asymmetry.

$$A_{LL} = \frac{N_{Signal+BG}}{N_{Signal}} A_{LL}^{Single+BG} - \frac{N_{BG}}{N_{Signal}} A_{LL}^{BG}$$

A_{LL} from signal window

A_{LL} from BG window



2 γ invariant mass distribution

But, there are 2 background A_{LL}s in di-π^0 analysis. So, we need to modify this formula.

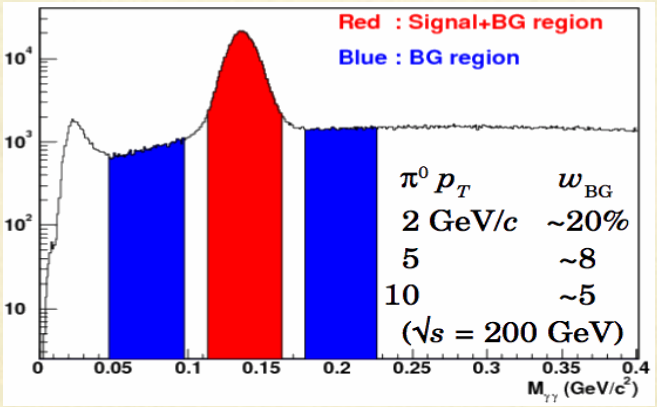
Our new background subtraction formula.

Well known formula for subtracting background asymmetry.

$$A_{LL} = \frac{N_{Signal+BG}}{N_{Signal}} A_{LL}^{Single+BG} - \frac{N_{BG}}{N_{Signal}} A_{LL}^{BG}$$

A_{LL} from signal window

A_{LL} from BG window



Our new background subtraction formula.

$$A_{LL} = \frac{N_{Signal+BG1+BG2}}{N_{Signal}} A_{LL}^{Single+BG1+BG2} - \frac{N_{BG1}}{N_{Signal}} A_{LL}^{BG1} - \frac{N_{BG2}}{N_{Signal}} A_{LL}^{BG2}$$

A_{LL} in signal window include 2 background A_{LL}

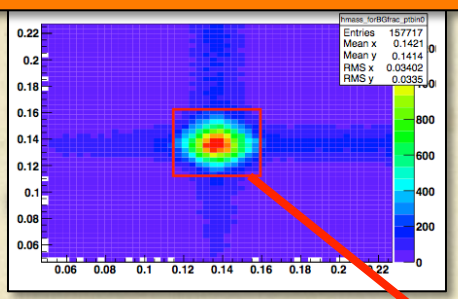
Well known formula for subtracting background asymmetry.

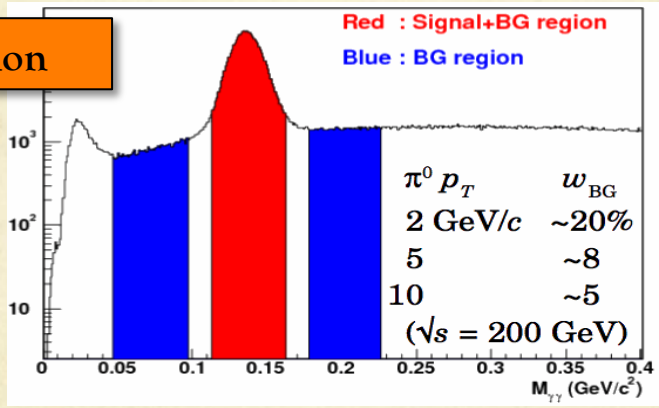
$$A_{LL} = \frac{N_{Signal+BG}}{N_{Signal}} A_{LL}^{Single+BG} - \frac{N_{BG}}{N_{Signal}} A_{LL}^{BG}$$

A_{LL} from signal window

A_{LL} from BG window

2D 2 γ invariant mass distribution





Our new background subtraction formula.

$$A_{LL} = \frac{N_{Signal+BG1+BG2}}{N_{Signal}} A_{LL}^{Single+BG1+BG2} - \frac{N_{BG1}}{N_{Signal}} A_{LL}^{BG1} - \frac{N_{BG2}}{N_{Signal}} A_{LL}^{BG2}$$

A_{LL} from signal window.

Subtract 2background asymmetry

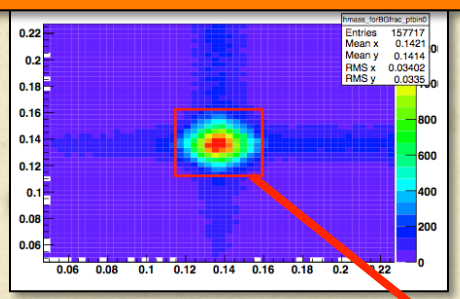
Well known formula for subtracting background asymmetry.

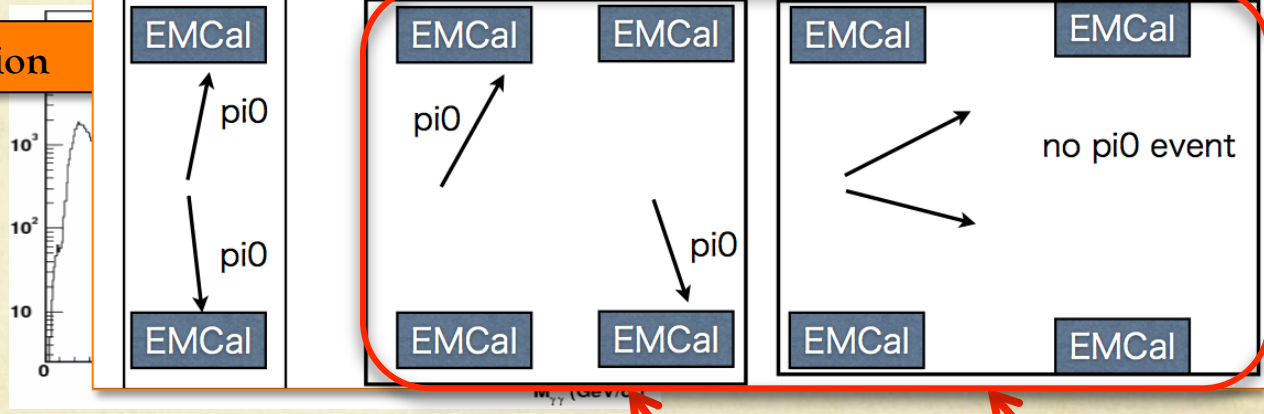
$$A_{LL} = \frac{N_{Signal+BG}}{N_{Signal}} A_{LL}^{Single+BG} - \frac{N_{BG}}{N_{Signal}} A_{LL}^{BG}$$

A_{LL} from signal window

A_{LL} from BG window

2D 2 γ invariant mass distribution





Our new background subtraction formula.

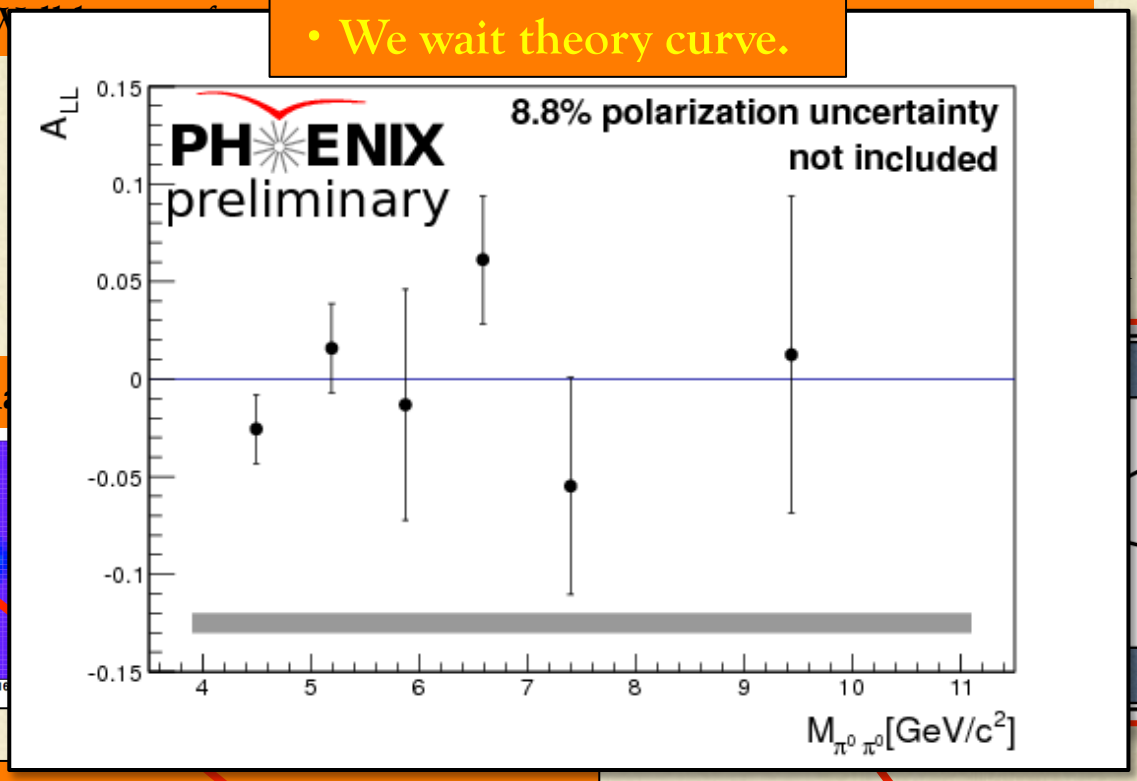
$$A_{LL} = \frac{N_{Signal+BG1+BG2}}{N_{Signal}} A_{LL}^{Single+BG1+BG2} - \frac{N_{BG1}}{N_{Signal}} A_{LL}^{BG1} - \frac{N_{BG2}}{N_{Signal}} A_{LL}^{BG2}$$

A_{LL} from signal window.

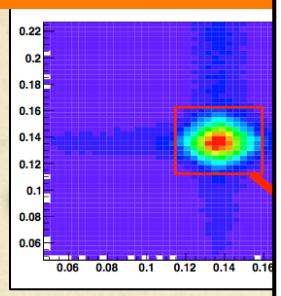
Background A_{LL}s

Subtract 2background asymmetry

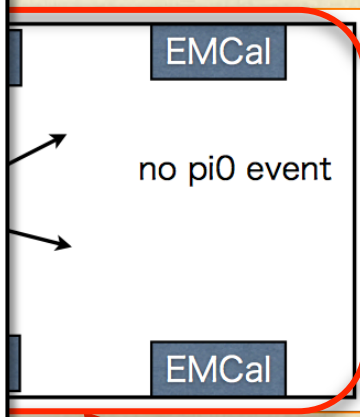
- Zero consistent.
- We wait theory curve.



2D 2 γ invariant ma



BG window



Our new background subtraction formula.

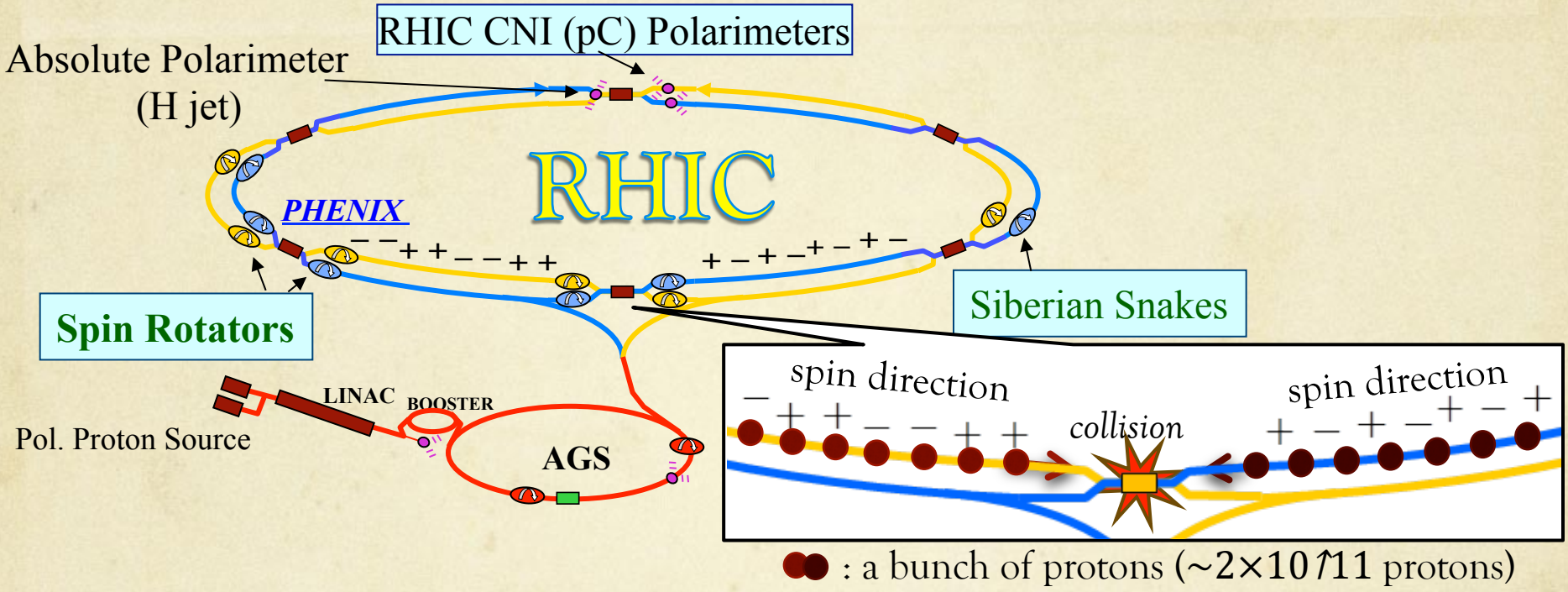
$$A_{LL} = \frac{N_{Signal+BG1+BG2}}{N_{Signal}} A_{LL}^{Single+BG1+BG2} - \frac{N_{BG1}}{N_{Signal}} A_{LL}^{BG1} - \frac{N_{BG2}}{N_{Signal}} A_{LL}^{BG2}$$

Summary

- PHENIX inclusive π^0 (05+06+09) prefer non-zero A_{LL}.
- To decide sign of ΔG, $\pi^{\pm}$ A_{LL} also important.
  - We are analyzing RUN09 data with HBD. We expect clean separation between various particles($e^{\pm}$,$\pi^{\pm}$,$K^{\pm}$).
- Cleaner channels
  - Single electron from heavy flavor ; We hope to analyze VTX data.
  - Direct Photon ; We are analyzing RUN09 data.
- New channel ; Di-π^0 A_{LL}
  - This is a first measurements of A_{LL} which was measured by "pair" objects in PHENIX Spin group.
  - The subsequent studies are π^0-$h^{\pm}$, π^0-Jet or Di-Jet A_{LL} in Central arm.
  - Di-Jet will be measured by sPHENIX Central Barrel and Forward.

Backups

Method of A_{LL} measurement



$$A_{LL} \equiv \frac{\sigma_{++} - \sigma_{+-}}{\sigma_{++} + \sigma_{+-}} = \frac{1}{P_Y P_B} \frac{N_{++} - R N_{+-}}{N_{++} + R N_{+-}}$$

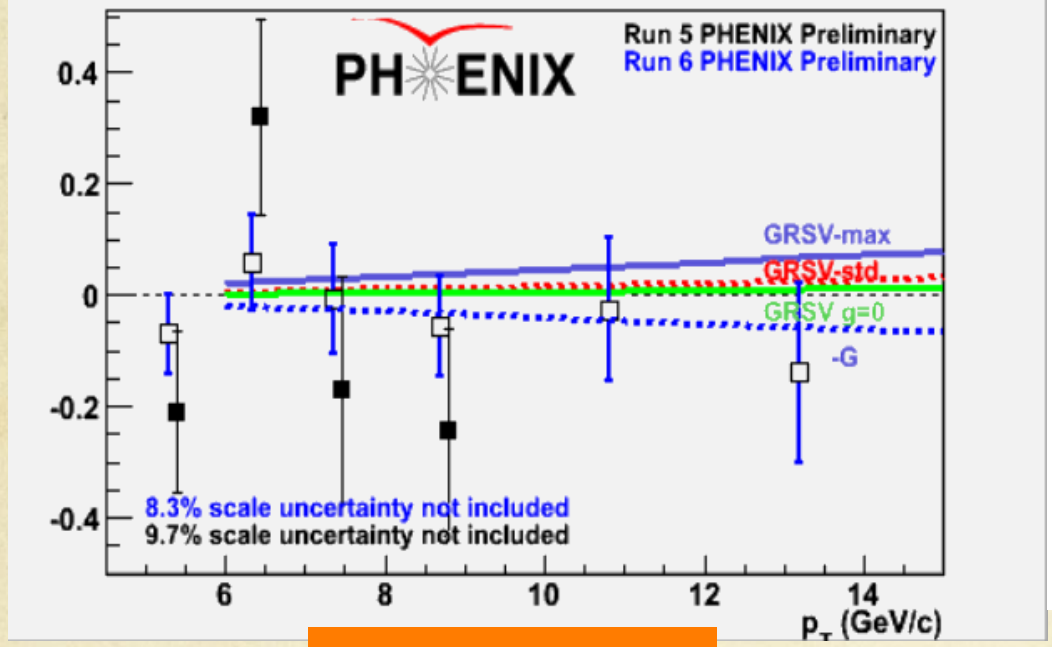
N_{++} ; Number of measured hadrons which come from helicity like coll.

R ; Relative Luminosity

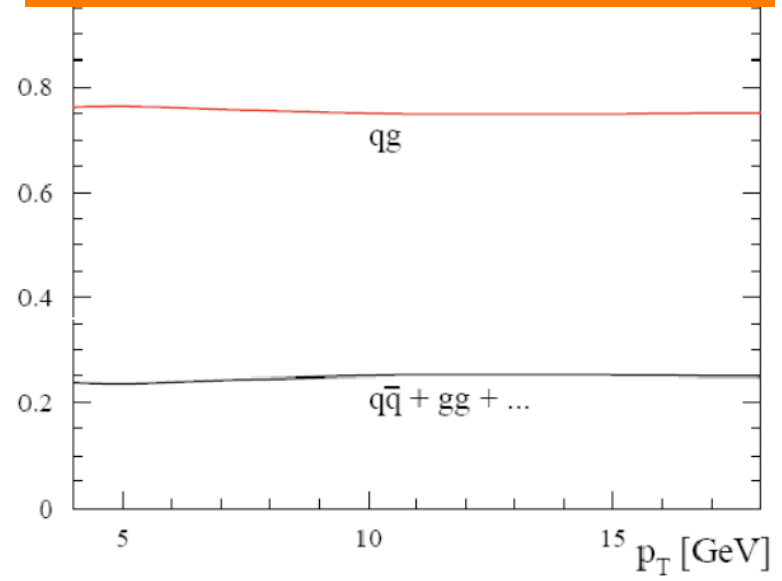
Direct Photon

have sensitivity of size and sign of ΔG

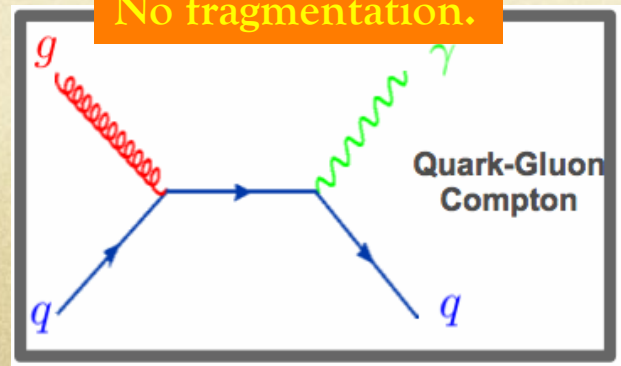
Now, We are analyzing RUN09 and 500GeV data.



q-g scattering is dominat subprocess.



No fragmentation.



- q-g scattering(75%) .
  + q-qbar annihilation(25%).
- Not need to consider FFs.
- Large photon background from π^0, η .
- Statistics limited.

The $\pi^{\pm}$ production have sensitivity for sign of gluon PDF

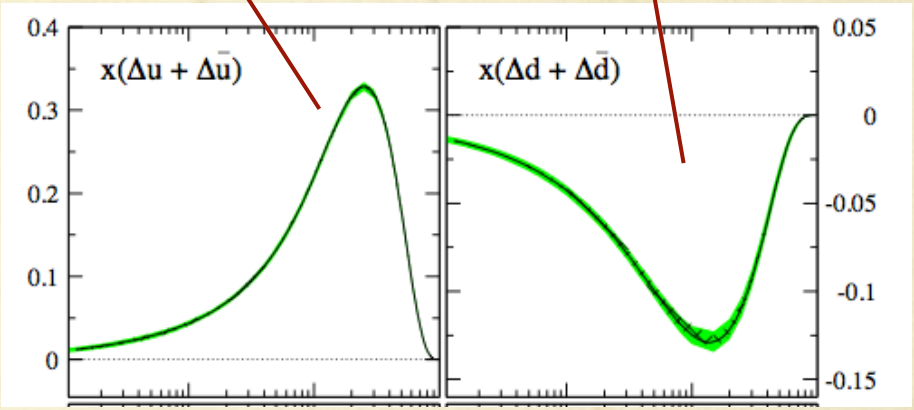
A_{LL} can write down.....

$$A_{LL}^{\pi+,-} \approx \Delta G_1 \Delta G_2 \hat{a}_{LL}^{gg} + \Delta G_1 \Delta u \hat{a}_{LL}^{gq} + \Delta G_1 \Delta d \hat{a}_{LL}^{gq} + \cdots$$

We know quarks PDF from DIS data.

A_{LL} can write down.....

$$A_{LL}^{\pi+,-} \approx \Delta G_1 \Delta G_2 \hat{a}_{LL}^{gg} + \Delta G_1 \Delta u \hat{a}_{LL}^{gq} + \Delta G_1 \Delta d \hat{a}_{LL}^{gq} + \cdots$$



We already know sign of quark's PDF.

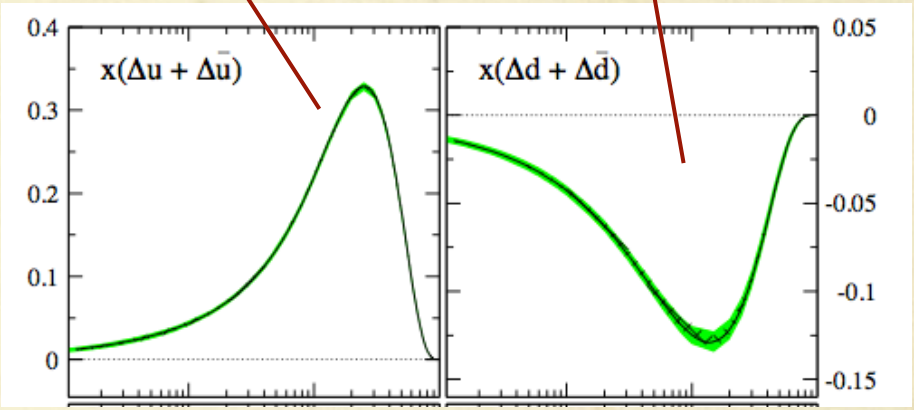
And we want to know sign of gluon PDF from $\pi^{\pm}$ production.

This is what we want to know.

A_{LL} can write down.....

$$A_{LL}^{\pi+,-} \approx \Delta G_1 \Delta G_2 \hat{a}_{LL}^{gg} + \Delta G_1 \Delta u \hat{a}_{LL}^{gq} + \Delta G_1 \Delta d \hat{a}_{LL}^{gq} + \cdots$$

>0 <0



We already know sign of quark's PDF.

In π^- production, $u \to \pi^-$ is larger than $d \to \pi^-$

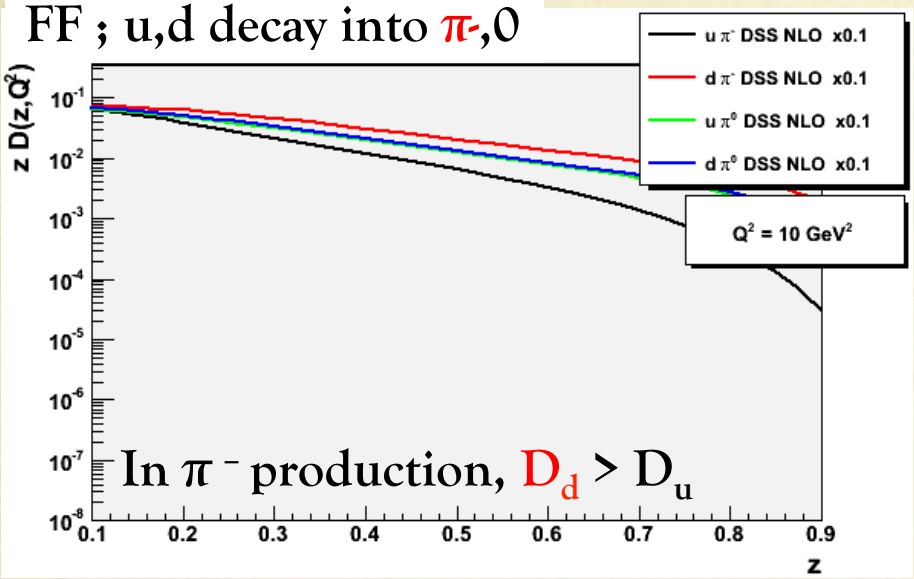
This is what we want to know.

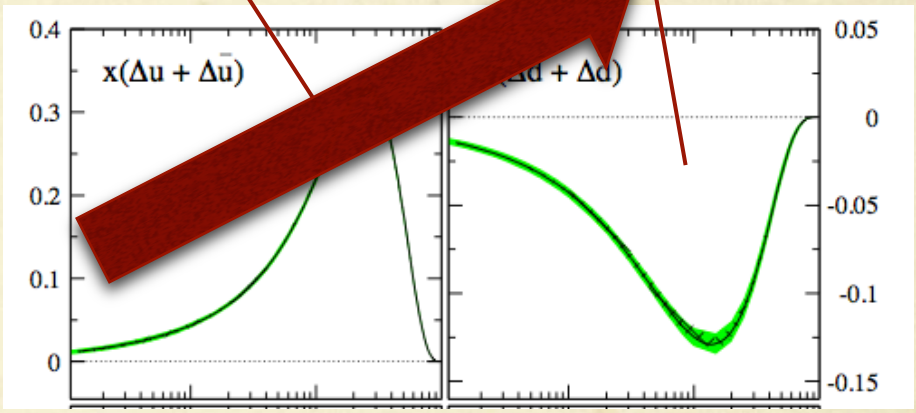
A_{LL} can write down.....

$$A_{LL}^{\pi+,-} \approx \Delta G_1 \Delta G_2 \hat{a}_{LL}^{gg} + \Delta G_1 \Delta u \hat{a}_{LL}^{gq} + \Delta G_1 \Delta d \hat{a}_{LL}^{gq} + \cdots$$

(Δu: >0, Δd: <0)

FF ; u,d decay into π^-,0





We already know sign of quark's PDF.

From PDFs,
Sing of u and ubar's PDF is positive.
Sign of d and dbar's PDF is negative.

From FFs,
In π^- production, $u \to \pi^-$ is larger than $d \to \pi^-$.

In π^+ production, $d \rightarrow \pi^+$ is larger than $u \rightarrow \pi^+$

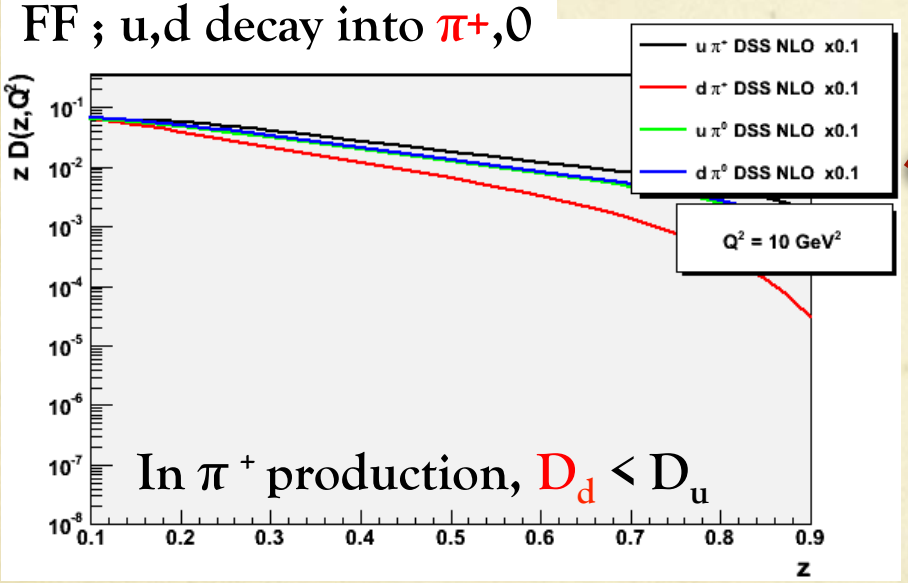
This is what we want to know.

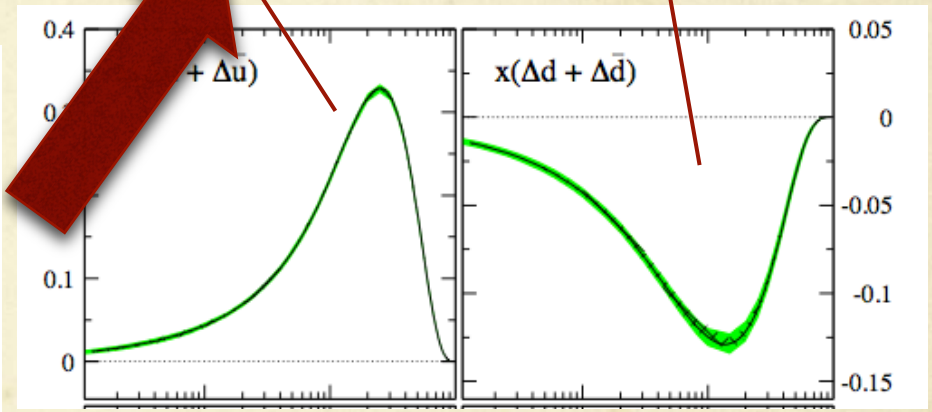
A_{LL} can write down.....

$$A_{LL}^{\pi+,-} \approx \Delta G_1 \Delta G_2 \hat{a}_{LL}^{gg} + \Delta G_1 \Delta u \hat{a}_{LL}^{gq} + \Delta G_1 \Delta d \hat{a}_{LL}^{gq} + \cdots$$

(Δu: >0, Δd: <0)

FF ; u,d decay into π+,0





We already know sign of quark's PDF.

From PDFs,
Sing of u and ubar's PDF is positive.
Sign of d and dbar's PDF is negative.

From FFs,
In π^+ production, $d \rightarrow \pi^+$ is larger than $u \rightarrow \pi^+$.

If $\Delta G>0$, A_{LL} of π^+ larger than A_{LL} of π^-

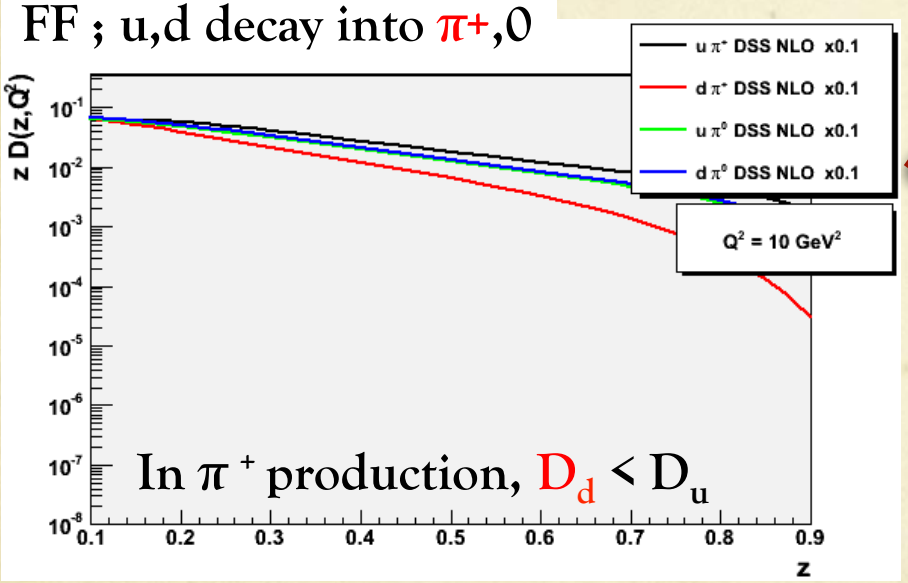
This is what we want to know.

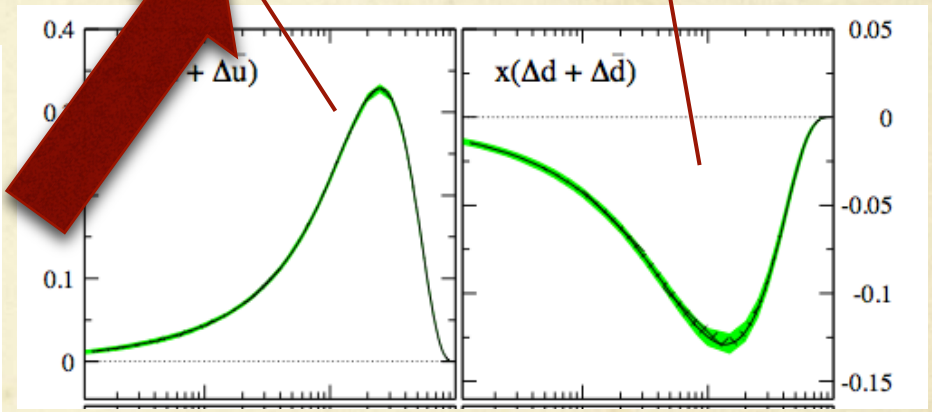
A_{LL} can write down.....

$$A_{LL}^{\pi+,-} \approx \Delta G_1 \Delta G_2 \hat{a}_{LL}^{gg} + \Delta G_1 \Delta u \hat{a}_{LL}^{gq} + \Delta G_1 \Delta d \hat{a}_{LL}^{gq} + \cdots$$

(Δu: >0, Δd: <0)

FF ; u,d decay into π+,0





We already know sign of quark's PDF.

From PDFs,
Sing of u and ubar's PDF is positive.
Sign of d and dbar's PDF is negative.

From FFs,
In π^+ production, d→π^+ is larger than u→π^+.

When $\Delta G > 0$, $A_{LL}^{\pi-} < A_{LL}^{\pi+}$

If $\Delta G<0$, A_{LL} of π^- larger than A_{LL} of π^+

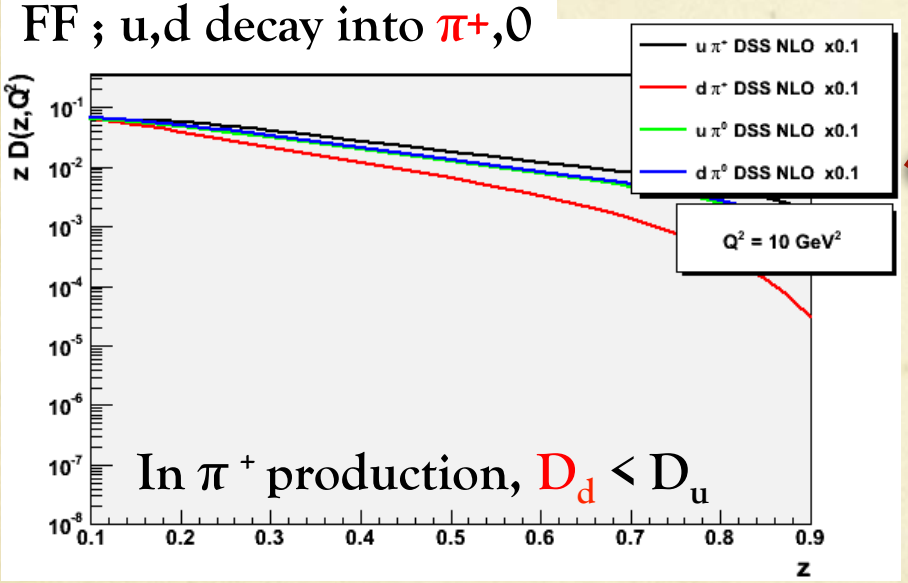
This is what we want to know.

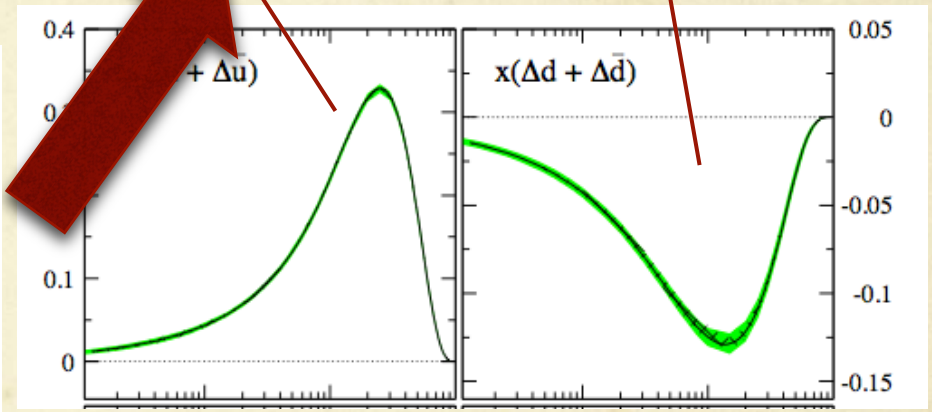
A_{LL} can write down.....

$$A_{LL}^{\pi+,-} \approx \Delta G_1 \Delta G_2 \hat{a}_{LL}^{gg} + \Delta G_1 \Delta u \hat{a}_{LL}^{gq} + \Delta G_1 \Delta d \hat{a}_{LL}^{gq} + \cdots$$

(Δu: >0, Δd: <0)

FF ; u,d decay into π+,0





We already know sign of quark's PDF.

From PDFs,
Sing of u and ubar's PDF is positive.
Sign of d and dbar's PDF is negative.

From FFs,
In π^+ production, d→π^+ is larger than u→π^+.

When $\Delta G < 0$, $A_{LL}^{\pi-} > A_{LL}^{\pi+}$